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# 14 Bit and 16 Bit
# Digital Storage Oscilloscope

C-Class Oscilloscope
Models ZT412VXI

User's Manual: 0004-000053
Revision 2a

January 9, 2008

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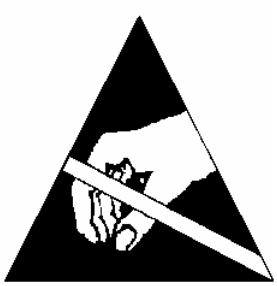
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- The work surface must be conductive and reliably connected to an earth ground with a safety resistance of approximately 250 kilohms.

- The surface must NOT be metal. A resistance of 30–300 kilohms per square inch is suggested.

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# Revision History

| Rev | Date | Section | Description |
|---|---|---|---|
| 1 | 04-24-06 | All | Initial Release |
| 2 | 04-30-07 | All | Bug fixes and C-Class release updates |
| 2A | 01-09-08 | All | Clean up and spelling corrections |



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# Table of Contents

**Introduction ..... 15**
Description ..... 15
Product Options and Part Numbers ..... 15
Front Panel ..... 16
Additional Resources ..... 17
**Functionality and Operation ..... 19**
Functional Block Diagram ..... 19
Data Flow ..... 20
Input Channels ..... 20
Input Channel Enable ..... 20
Input Signal Conditioning ..... 21
Input Coupling ..... 21
Input Impedance ..... 21
Input Range ..... 21
Input Offset ..... 21
Sweep Controls ..... 22
Record Size and Sampling Rate ..... 22
Time Base Reference Clock ..... 23
Internal and External Sampling Clock ..... 23
Record Length and Sweep ..... 23
Sweep Reference Scenarios ..... 23
Averager Controls ..... 24
Averager Considerations ..... 25
Acquisition Types ..... 25
Trigger and Arm Controls ..... 26
Trigger Initiate Model ..... 26
Trigger Processing ..... 27
Trigger Types ..... 28
Software Trigger ..... 28
Edge Trigger ..... 28
Pulse Width Trigger ..... 28
Pattern Trigger ..... 29
Video Trigger ..... 29
Event Trigger ..... 29
Trigger B ..... 29
Arm ..... 29
Trigger Timestamp ..... 29
Outputs ..... 30
Trigger Outputs ..... 30
Reference Output ..... 30
Calculate Controls ..... 30
Calculate Functions ..... 31
Add ..... 31
Subtract ..... 31
Multiply ..... 31
Copy ..... 31
Invert ..... 31
Integral ..... 31



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Derivative ..... 31
Absolute Value ..... 31
Limit Test ..... 31
Mask Test ..... 32
Frequency Transform ..... 32
Time Domain Transform ..... 34
Measure Controls ..... 34
Time Domain Measurements ..... 34
Frequency-Domain Measurements ..... 38
Invalid Measurements ..... 39
Voltage Measurements ..... 39
RMS Measurements ..... 40
Cycle and Width Measurements ..... 40
Edge Measurements ..... 40
Frequency-Domain Measurements ..... 41
Measurement Method ..... 41
Entire Waveform ..... 41
Gated by Time ..... 41
Gated by Points ..... 42
Measurement Reference Levels ..... 42
Measurement Edge ..... 42
Waveform and Reference ..... 42
Read Waveform ..... 42
Read Waveform Preamble ..... 42
Header Information ..... 43
Time Axis Information ..... 43
Voltage Axis Information ..... 43
Reference Waveform ..... 43
Utilities and Status Reporting ..... 43
Auto Scale ..... 43
Reset and Device Clear ..... 44
Save and Recall States ..... 44
Error ..... 44
Status ..... 44
Condition ..... 44
Event ..... 45
Enable ..... 45
Status Commands and Queries ..... 47
Self Test ..... 50
Calibrate ..... 50
Identification and Version ..... 51
**VXI Interface ..... 53**
Interface Description ..... 53
VXIbus Interface ..... 53
ID Register ..... 54
Device Type Register ..... 54
Status/Control Register ..... 55
Offset Register ..... 56
Protocol Register ..... 56
Response Register ..... 57
Data Low Register ..... 57



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A32 Address Space ..... 58
Writing to the ZT412 ..... 58
Reading from the ZT412 ..... 58
Low-Level VXIbus Commands ..... 58
**Command Reference ..... 61**
Common Command Format ..... 61
SCPI Command Format ..... 61
Command Separator ..... 62
Abbreviated Commands ..... 62
Implied Commands ..... 62
Parameters ..... 63
Optional Parameters ..... 64
Parameters Out of Range ..... 64
Linking Commands ..... 64
Linking IEEE 488.2 Common Commands with SCPI Commands ..... 64
Linking Multiple SCPI Commands ..... 64
IEEE 488.2 Common Commands ..... 65
Calibrate Query ..... 65
Clear Status Command ..... 65
Event Status Enable Command ..... 66
Event Status Enable Query ..... 66
Event Status Register Query ..... 66
Identification Query ..... 67
Operation Complete Command ..... 67
Operation Complete Query ..... 67
Recall Instrument State Command ..... 68
Reset Command ..... 68
Save Instrument State Command ..... 68
Service Request Enable Command ..... 69
Service Request Enable Query ..... 69
Status Byte Query ..... 69
Trigger Immediate Command ..... 70
Test Query ..... 70
Wait to Continue Command ..... 71
SCPI Commands and Queries ..... 72
Abort Command ..... 72
Arm Command ..... 72
Arm Polarity Command ..... 73
Arm Polarity Query ..... 73
Arm Source Command ..... 74
Arm Source Query ..... 74
Auto Scale Command ..... 74
Average Count Command ..... 75
Average Count Query ..... 75
Average Envelope View Command ..... 76
Average Envelope View Query ..... 76
Average Equivalent Time Points Command ..... 77
Average Equivalent Time Points Query ..... 77
Average State Command ..... 78
Average State Query ..... 78
Average Type Command ..... 79



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Average Type Query ..... 79
Calculate Absolute Value Command ..... 80
Calculate Add Command ..... 81
Calculate Copy Command ..... 82
Calculate Data Format Command ..... 83
Calculate Data Format Query ..... 83
Calculate Derivative Command ..... 84
Calculate Function Query ..... 85
Calculate Immediate Command ..... 86
Calculate Integral Command ..... 86
Calculate Invert Command ..... 87
Calculate Limit Test Clear Command ..... 87
Calculate Limit Test Command ..... 88
Calculate Limit Test Continuous Command ..... 88
Calculate Limit Test Continuous Query ..... 88
Calculate Limit Test Fail Query ..... 89
Calculate Limit Test Lower Command ..... 89
Calculate Limit Test Lower Query ..... 89
Calculate Limit Test Measurement Command ..... 90
Calculate Limit Test Measurement Query ..... 90
Calculate Limit Test Report Query ..... 91
Calculate Limit Test Upper Command ..... 91
Calculate Limit Test Upper Query ..... 91
Calculate Mask Test Lower Command ..... 92
Calculate Mask Test Lower Query ..... 92
Calculate Mask Test Upper Command ..... 93
Calculate Mask Test Upper Query ..... 93
Calculate Multiply Command ..... 94
Calculate State Command ..... 95
Calculate State Query ..... 95
Calculate Subtract Command ..... 96
Calculate Transform Frequency Command ..... 97
Calculate Transform Frequency Window Command ..... 97
Calculate Transform Frequency Window Query ..... 97
Calculate Transform Time Command ..... 98
Calculate Transform Time Points Command ..... 98
Calculate Transform Time Points Query ..... 98
Calculate Voltage Offset Command ..... 99
Calculate Voltage Offset Query ..... 99
Calculate Voltage Range Command ..... 99
Calculate Voltage Range Query ..... 99
Calibration Restore Command ..... 100
Calibration Skew Command ..... 100
Calibration Skew Query ..... 100
Clock Frequency Command ..... 101
Clock Frequency Query ..... 101
Clock Source Command ..... 102
Clock Source Query ..... 102
Format Byte Command ..... 102
Format Byte Query ..... 102
Initiate Command ..... 102



Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Initiate Query ..... 102
Initiate Continuous Command ..... 103
Initiate Continuous Query ..... 103
Input Attenuation Command ..... 103
Input Attenuation Query ..... 103
Input Coupling Command ..... 104
Input Coupling Query ..... 104
Input Impedance Command ..... 105
Input Impedance Query ..... 105
Input State Command ..... 105
Input State Query ..... 105
Input Voltage Offset Command ..... 106
Input Voltage Offset Query ..... 106
Input Voltage Protection State Command ..... 107
Input Voltage Protection State Query ..... 107
Input Voltage Range Command ..... 108
Input Voltage Range Query ..... 108
Measure AC High-Precision Query ..... 109
Measure AC RMS Query ..... 110
Measure Amplitude Query ..... 111
Measure Average Voltage Query ..... 112
Measure Cycle Average Query ..... 113
Measure Cycle Frequency Query ..... 114
Measure Cycle Period Query ..... 115
Measure Cycle RMS Query ..... 116
Measure DC High-Precision RMS Query ..... 117
Measure DC RMS Query ..... 118
Measure Edge Command ..... 118
Measure Edge Query ..... 118
Measure Effective Number of Bits Query ..... 119
Measure Fall Crossing Time Query ..... 120
Measure Fall Overshoot Query ..... 121
Measure Fall Preshoot Query ..... 122
Measure Fall Time Query ..... 123
Measure Frequency Query ..... 124
Measure Gate Points Command ..... 124
Measure Gate Points Query ..... 124
Measure Gate Time Command ..... 125
Measure Gate Time Query ..... 125
Measure High Voltage Query ..... 125
Measure Low Voltage Query ..... 126
Measure Maximum Voltage Query ..... 127
Measure Method Command ..... 128
Measure Method Query ..... 128
Measure Mid Voltage Query ..... 129
Measure Minimum Voltage Query ..... 130
Measure Negative Duty Cycle Query ..... 131
Measure Negative Width Query ..... 132
Measure Peak-To-Peak Voltage Query ..... 133
Measure Period Query ..... 134
Measure Phase Query ..... 135



Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Measure Positive Duty Cycle Query ..... 136
Measure Positive Width Query ..... 137
Measure Reference Command ..... 138
Measure Reference Query ..... 138
Measure Reference Method Command ..... 139
Measure Reference Method Query ..... 139
Measure Rise Crossing Time Query ..... 139
Measure Rise Overshoot Query ..... 140
Measure Rise Preshoot Query ..... 141
Measure Rise Time Query ..... 142
Measure Signal-to-Noise Ratio Query ..... 143
Measure Signal-to-Noise and Distortion Ratio Query ..... 144
Measure Spurious-Free Dynamic Range Query ..... 145
Measure Time/Frequency of Maximum Voltage Query ..... 146
Measure Time/Frequency of Minimum Voltage Query ..... 147
Measure Total Harmonic Distortion Query ..... 148
Output ECL Trigger Polarity Command ..... 149
Output ECL Trigger Polarity Query ..... 149
Output ECL Trigger Source Command ..... 150
Output ECL Trigger Source Query ..... 150
Output ECL Trigger State Command ..... 151
Output ECL Trigger State Query ..... 151
Output Reference Source Command ..... 152
Output Reference Source Query ..... 152
Output Reference State Command ..... 152
Output Reference State Query ..... 152
Output TTL Trigger Polarity Command ..... 153
Output TTL Trigger Polarity Query ..... 153
Output TTL Trigger Source Command ..... 154
Output TTL Trigger Source Query ..... 154
Output TTL Trigger State Command ..... 155
Output TTL Trigger State Query ..... 155
Reference Oscillator Source Command ..... 155
Reference Oscillator Source Query ..... 155
Status Calibration Condition Query ..... 156
Status Calibration Enable Command ..... 157
Status Calibration Enable Query ..... 157
Status Calibration Event Query ..... 158
Status Frequency Condition Query ..... 159
Status Frequency Enable Command ..... 160
Status Frequency Enable Query ..... 160
Status Frequency Event Query ..... 161
Status Operation Condition Query ..... 162
Status Operation Enable Command ..... 163
Status Operation Enable Query ..... 163
Status Operation Event Query ..... 164
Status Preset Command ..... 165
Status Questionable Condition Query ..... 165
Status Questionable Enable Command ..... 166
Status Questionable Event Query ..... 167
Status Test Condition Query ..... 168



Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Status Test Enable Command ..... 169
Status Test Enable Query ..... 169
Status Test Event Query ..... 170
Status Voltage Condition Query ..... 171
Status Voltage Enable Command ..... 172
Status Voltage Enable Query ..... 172
Status Voltage Event Query ..... 173
Sweep Mode Command ..... 174
Sweep Mode Query ..... 174
Sweep Offset Reference Command ..... 175
Sweep Offset Reference Query ..... 175
Sweep Offset Time Command ..... 176
Sweep Offset Time Query ..... 176
Sweep Points Command ..... 177
Sweep Points Query ..... 177
Sweep Time Query ..... 178
System Delay Bypass Command ..... 178
System Delay Bypass Query ..... 178
System Error All Query ..... 179
System Error Count Query ..... 179
System Error Query ..... 180
System Memory Query ..... 180
System Version Query ..... 181
Trace Data Command ..... 182
Trace Data Query ..... 182
Trace Copy Reference Command ..... 183
Trace Load Calculate Query ..... 184
Trace Load Input Query ..... 185
Trace Load Reference Command ..... 186
Trace Load Reference Query ..... 186
Trace Preamble Command ..... 186
Trace Preamble Query ..... 186
Trigger A Event Count Command ..... 188
Trigger A Event Count Query ..... 188
Trigger A Pulse High Limit Command ..... 189
Trigger A Pulse High Limit Query ..... 189
Trigger A Pulse Low Limit Command ..... 190
Trigger A Pulse Low Limit Query ..... 190
Trigger A Slope Command ..... 191
Trigger A Slope Query ..... 191
Trigger A Source Command ..... 192
Trigger A Source Query ..... 192
Trigger A Type Command ..... 193
Trigger A Type Query ..... 193
Trigger A Video Field Command ..... 194
Trigger A Video Field Query ..... 194
Trigger A Video Line Command ..... 194
Trigger A Video Line Query ..... 194
Trigger A Video Standard Command ..... 195
Trigger A Video Standard Query ..... 195
Trigger B Slope Command ..... 195



Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Trigger B Slope Query ..... 195
Trigger B Source Command ..... 196
Trigger B Source Query ..... 196
Trigger B State Command ..... 196
Trigger B State Query ..... 196
Trigger Hold Off Command ..... 197
Trigger Hold Off Query ..... 197
Trigger External Level Command ..... 198
Trigger External Level Query ..... 198
Trigger Input Level Command ..... 198
Trigger Input Level Query ..... 198
Trigger Pattern Mask Command ..... 199
Trigger Pattern Mask Query ..... 199
Trigger Pattern Truth Command ..... 200
Trigger Pattern Truth Query ..... 200
Trigger Timestamp Query ..... 200

**Specifications ..... 201**
Analog Input ..... 201
Analog-to-Digital Converter ..... 202
Waveform Memory ..... 203
Acquisition Modes ..... 203
Trigger ..... 204
External Trigger Input ..... 205
Trigger Outputs ..... 205
Reference Output ..... 205
Arm ..... 205
External Arm Input ..... 205
External Sampling Clock Input ..... 206
10 MHz Time Base Reference ..... 206
Data Processing ..... 206
Measurements ..... 206
Reference Waveforms ..... 207
Calculations ..... 207
Instrument Setup Storage ..... 207
Data Interface ..... 208
VXIbus P2 Trigger & Clock Pin Usage ..... 208
LED Indicators ..... 208
DC Power ..... 209
Physical ..... 209
Temperature Range ..... 210
Relative Humidity ..... 210
Altitude ..... 210

**Default Reset Conditions ..... 211**

**Error Codes ..... 215**

**Commands Index ..... 223**
IEEE-488 Common Commands ..... 223
SCPI Instrument Specific Commands ..... 223



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# List of Figures

Figure 1: Photo of the ZT412VXI ..... 16
Figure 2: ZT412VXI Front Panel ..... 17
Figure 3: ZT412 Block Diagram ..... 19
Figure 4: Data Flow ..... 20
Figure 5: ZT412 Sweep Reference Scenarios ..... 24
Figure 6: Equivalent Time Acquisition ..... 26
Figure 7: Trigger Initiate Model ..... 27
Figure 8: Trigger Processing ..... 28
Figure 9: Vertical-Axis Measurement Terminology ..... 36
Figure 10: Horizontal-Axis Measurement Terminology ..... 37
Figure 11: Edge Measurement Terminology ..... 37
Figure 12: Frequency-Domain Measurement Terminology ..... 38
Figure 13: Invalid Voltage Measurements ..... 40
Figure 14: Invalid Edge Measurements ..... 41
Figure 15: Status Register ..... 46

# List of Tables

Table 1: ZT412VXI Product Options ..... 15
Table 2: ZT412VXI Front Panel Connectors ..... 16
Table 3: Sample Rates and Bandwidths of Product Options ..... 20
Table 4: Input Voltage Range and Offset ..... 22
Table 5: FFT Sample Range and Size ..... 33
Table 6: FFT Window Comparison ..... 33
Table 7: System Status ..... 49
Table 8: Self-Test Errors ..... 50
Table 9: VXIbus A16 Address Space ..... 53
Table 10: VXIbus A32 Address Space ..... 53
Table 11: ID Register Bit Descriptions (Read-Only) ..... 54
Table 12: Device Type Register Bit Descriptions (Read-Only) ..... 54
Table 13: Control Register Bit Descriptions (Write-Only) ..... 55
Table 14: Status Register Bit Descriptions (Read-Only) ..... 55
Table 15: Offset Register Bit Descriptions (Read/Write) ..... 56
Table 16: Protocol Register Bit Descriptions (Read-Only) ..... 56
Table 17: Response Register Bit Descriptions (Read-Only) ..... 57
Table 18: Data Low Register Bit Descriptions (Read-Write) ..... 57
Table 19: Low-Level VXIbus Commands ..... 59
Table 20: Parameter Types ..... 63



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# Introduction



## Description

The Model ZT412VXI (See Figure 1) is a 14-bit or 16-bit Digital Storage Oscilloscope. It is built around a high speed, deep memory sequencer and embedded TMS320VC5409 Digital Signal Processor (DSP) housed within a single-wide C-size VXIbus instrument. Together with the host processor and software, it provides a simple powerful way to capture and analyze wide bandwidth analog, IF, and low frequency RF signals.

Initiated by trigger events from both internal and external sources, the ZT412VXI digitizes signals in user-selectable record sizes. Analog signal processing allows selectable four channel operation, input impedance, AC or DC coupling, and input signal gain and offset. Waveform records are transferred from the digitizer into DSP memory, which can then be accessed from the VXIbus. Built-in DSP functions provide a variety of signal analysis and signal manipulation resources. All scope operations are controlled from an intuitive, software-based user interface running on the VXIbus host processor.

### Product Options and Part Numbers

| Part Number | Maximum Sample Rate | Sampling Resolution | Memory | Manual Naming |
|---|---|---|---|---|
| **ZT412VXI-20** | 500 MS/s | 14-bit | 1 MSample | ZT412-2X |
| **ZT412VXI-21** | 500 MS/s | 14-bit | 16 MSample | ZT412-2X |
| **ZT412VXI-50** | 400 MS/s | 16-bit | 1 MSample | ZT412-5X |
| **ZT412VXI-51** | 400 MS/s | 16-bit | 16 MSample | ZT412-5X |

**Table 1: ZT412VXI Product Options**

Table 1 shows the product options for the ZT412VXI that define maximum sample rate, bandwidth and memory size. The first digit of the option field defines the maximum sample rate between 500 and 400 million samples-per-second (MS/s) and the analog-to-digital converter (ADC) sampling resolution of either 14 bits or 16 bits. The second digit of the option field selects the memory size of either 1 or 16 million samples (MS). Within this manual, the entire ZT412VXI product line shall hereafter be designated as ZT412. When referring to specific product options, this manual shall use the naming convention shown in the rightmost column of Table 1.



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**Figure 1: Photo of the ZT412VXI**

# Front Panel

A diagram of the ZT412VXI front panel is shown in Figure 2. Table 2 lists the front panel connector functions.

| Label | Description |
|---|---|
| Channel 1 | Channel 1 input signal (BNC Connector) |
| Channel 2 | Channel 2 input signal (BNC Connector) |
| Channel 3 | Channel 3 Input Signal (BNC Connector) |
| Channel 4 | Channel 4 input signal (BNC Connector) |
| REF OUT | Reference Output (BNC Connector) |
| TRG IN | External Trigger Input (BNC Connector) |
| CLK IN | External Clock Input (BNC Connector) |
| ARM IN | External Arm Input (BNC Connector) |

**Table 2: ZT412VXI Front Panel Connectors**



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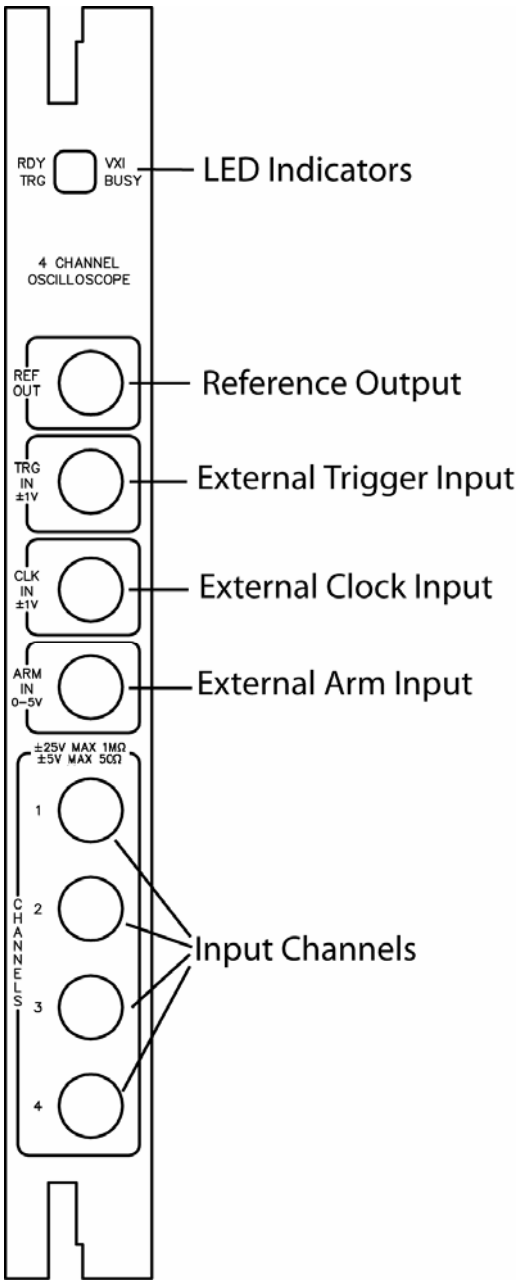



**Figure 2: ZT412VXI Front Panel**

# Additional Resources

ZTEC Instruments, Inc. offers several hardware and software resources to use with the ZT4610 series. Please visit the website www.ztecinstruments.com for the latest information and versions. Detailed information is also available in the individual manuals. Resources include: ZScope™ C-Class soft front panel, instrument drivers, cables and probes.



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# Functionality and Operation



## Functional Block Diagram

The functional blocks of the ZT412 are shown in Figure 3. Analog inputs are conditioned and digitized by the Input Channels. The acquisition time base record size and record placement with regard to the trigger event are configured by the Sweep Controls. Triggers are conditioned and selected by the Trigger and Arm Controls. Averager controls enable the instrument to capture the applied signal multiple times to create the resulting waveform record. Once captured, waveforms are manipulated and analyzed by the Calculate Controls. Waveform measurements, returning data from the ZT412, are handled by the Measure Controls. Status reporting and system utilities are handled by Utilities and Status Reporting. And finally, the data is stored for use and retrieval, and referenced by Waveform and Reference.

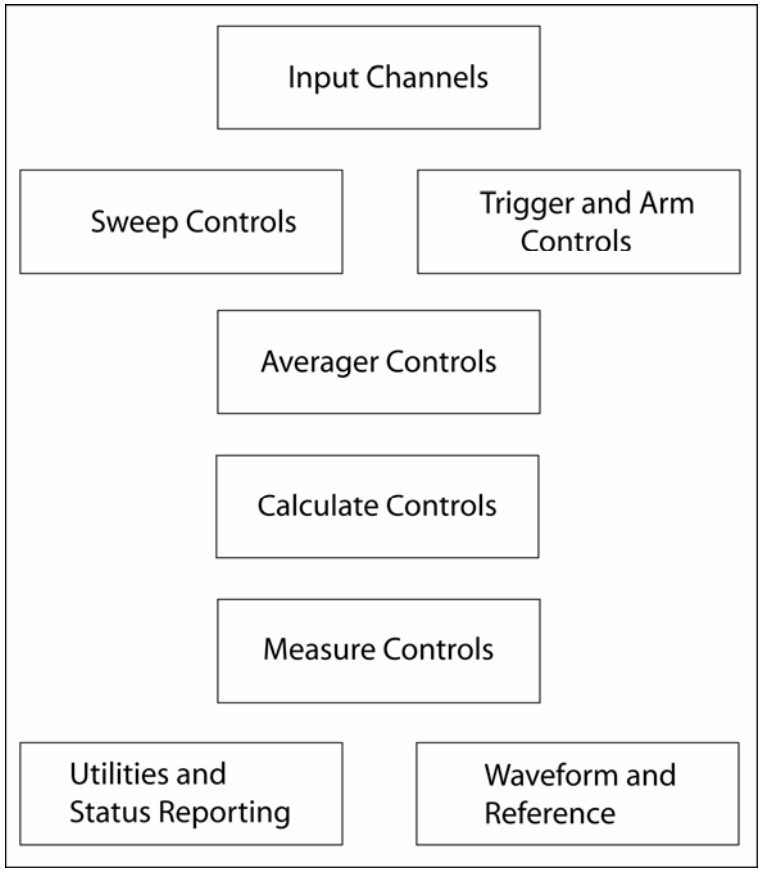



**Figure 3: ZT412 Block Diagram**



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# Data Flow

The data flow of the ZT412 is shown in Figure 4. Raw data is input through the four input channels (See *Input Channels* below). Next, the data flows to the Averager, which enables the instrument to acquire multiple waveforms to create the resulting waveform record. The ZT412 has four types of available acquisition: normal, average, envelope, and equivalent-time (See *Averager Controls*). New waveforms can now be mathematically created in the ZT412. The unit has two calculate channels, each capable of a 32K maximum waveform size (See *Calculate Controls*). Scalar measurements are possible using the *Measure Controls*. The ZT412 is capable of providing measurements using the following methods: Entire Waveform, Gated by Time, and Gated by Points. The ZT412 can save and download up to 4 reference waveforms. The reference waveforms, REF1–4, are stored in non-volatile Flash memory and are maintained when the unit is powered off. These waveforms are limited to record sizes of 32 kSamples.

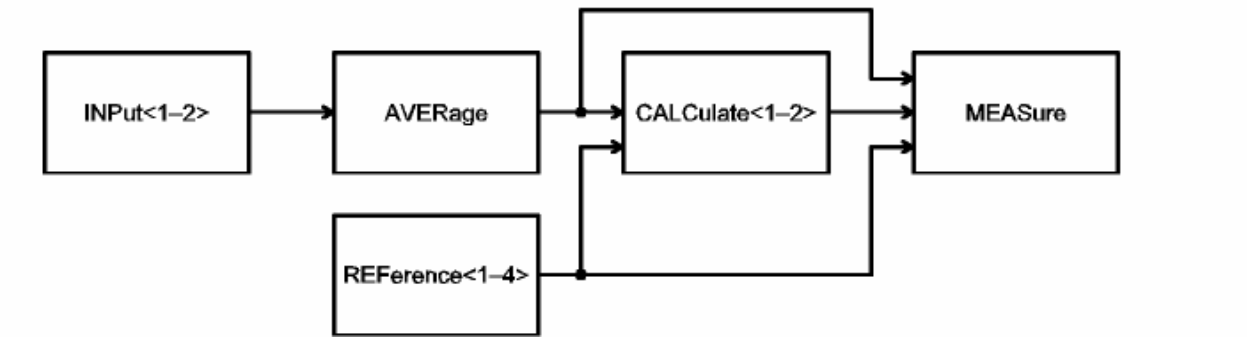



**Figure 4: Data Flow**

# Input Channels

| Product Option | 1 Channel Maximum Sample Rate | 2 Channel Maximum Sample Rate | Sampling Resolution |
|---|---|---|---|
| **ZT412-2X** | 500 MS/s | 250 MS/s | 14-bit |
| **ZT412-5X** | 400 MS/s | 200 MS/s | 16-bit |

**Table 3: Sample Rates and Bandwidths of Product Options**

## Input Channel Enable

The ZT412 allows capture of four input signals at rates from 10 kS/s up to one-half the maximum sample rate. Two interleaved channels can be sampled at the maximum sample rate. The maximum sample rate is 500 MS/s for the ZT412-2X and 400 MS/s for the ZT412-5X.



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## Input Signal Conditioning

The ZT412 provides signal conditioning to optimize input signal integrity. The analog bandwidth is DC to 250 MHz. User-configurable analog signal conditioning allows selection of input coupling, impedance, range, and offset.

## Input Coupling

Input coupling can be selected as AC or DC (see the *Input Coupling Command*). Selecting AC causes a highpass filter to be inserted before the input amplifiers to limit the input signal frequency: 200 KHz for low impedance (50Ω) and 10 Hz for high impedance (1 MΩ). Selecting DC coupling bypasses the AC coupling filter.

## Input Impedance

Input impedance can be selected as 50 Ω or as 1 MΩ (see the *Input Impedance Command*). Input load protection automatically switches from 50 Ω to 1 MΩ if voltages exceeding ±6 VDC are detected.



**CAUTION**

Do not apply signals having a peak value over ±25 VDC when using the high impedance (1MΩ) setting as unit damage may result.

Do not apply signals having a peak value over ±5 VDC when using the low impedance (50Ω) setting as unit damage may result.

## Input Range

A variable gain input amplifier allows selection of voltage ranges up to 10 Volts peak-to-peak (Vpp) for the 50 Ω setting and up to 50 Vpp for the 1 MΩ setting (see the *Input Voltage Range Command*).

**Note:** The input voltage range and input impedance are interrelated. When changing the input impedance, always resend the input voltage range setting.

## Input Offset

The *Input Voltage Offset Command* is used to set the specified input channel voltage offset. The offset range is shown in the following table:



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| Impedance | Range | Offset |
|---|---|---|
| 1 MΩ | 50 Vpp | 0V |
| | 25 Vpp | ±12.5V |
| | 10 Vpp | ±5V |
| | 5 Vpp | ±5V |
| | 2.5 Vpp | ±5V |
| | 1.25 Vpp | ±5V |
| | 0.5 Vpp | ±5V |
| | 0.25 Vpp | ±5V |
| 50Ω | 10 Vpp | 0V |
| | 5 Vpp | ±2.5V |
| | 2 Vpp | ±1V |
| | 1 Vpp | ±1V |
| | 0.5 Vpp | ±1V |
| | 0.25 Vpp | ±1V |
| | 0.1 Vpp | ±1V |
| | 0.05 Vpp | ±1V |

**Table 4: Input Voltage Range and Offset**

**Note:** When setting the input voltage offset and range, an incompatible range and offset combination may occur if the commands are sent in the wrong order. In order to preclude setting an incompatible offset, set the offset to 0.0V before changing the range to the new setting.

# Sweep Controls

The ZT412 provides a set of user-selectable sweep controls that enable the user to adjust the sample rate, timing, record size, and trigger position of the waveform capture process.

## Record Size and Sampling Rate

Acquisition record size is specified in sample points. Valid sizes range from 100 points to the full digitizer memory size. Acquisition sample rates can be selected over a range from 10 kS/s to the maximum sample rate. The available rate selections are based on the traditional 1, 2.5, 4 and 5 steps. Four input signals can be sampled simultaneously at rates from 10 kS/s up to one-half the maximum sample rate. Two interleaved channels can be sampled at the maximum sample rate. The maximum sample rate is 500 MS/s for the ZT412-2X and 400 MS/s for the ZT412-5X. The time duration of the sample record can be calculated by dividing the number of points by the sample rate or by multiplying the number of points by the sample interval.



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## Time Base Reference Clock

The ZT412 supports flexible time base reference configurations. The 10 MHz time base reference is used to synchronize all internal timing including the sampling clock for the digitizer. The source of the time base reference is selectable between an internal temperature-compensated crystal oscillator (TCXO) and the VXIbus backplane CLK10 reference signal. The time base frequency must be 10 MHz ±100 ppm. The internal TCXO reference provides ±2.5 ppm frequency accuracy. The reference oscillator source is selected using the *Reference Oscillator Source Command*.

## Internal and External Sampling Clock

The ZT412 supports flexible ADC sampling clock configurations. An internal sampling clock is generated by a phase-locked loop that is locked to the 10 MHz time base reference. The external sampling clock may be used to replace the onboard sampling clock for external synchronization or to achieve a sampling rate that cannot be specified by using the onboard clock. When two channels are enabled, the sampling occurs at the applied external frequency. When all channels are enabled, the sampling occurs at one-half the applied external frequency. The front panel sampling clock input has a clock rate range of 40 MHz to 500 MHz, a maximum input of ±5 V (no damage), and an input signal level of 500 mVpp to 1 Vpp (sine or square wave). The input is AC coupled into 50Ω, with an impedance accuracy of ±2%.

When using an external sample clock, the external source must be present before sending the *Clock Source Command*. Also, because the number of enabled channels affects the sample rate, the channel enable configuration must be set before sending the *Clock Source Command*. The external clock frequency must be entered using the *Clock Frequency Command* to properly set up the acquisition timing parameters. If the external clock frequency changes, the new frequency must be entered after the external clock has settled at the new frequency.

## Record Length and Sweep

The record length and corresponding record sweep time are controlled using the *Sweep Points Command/Query* and *Sweep Time Query*. Record lengths can range from 100 Samples up to 8 MSamples per channel, or up to 16 MSamples/channel (using 2 channels interleaved). Memory options for the ZT412 are 2 MSamples and 32 MSamples total.

The ZT412 provides two sweep modes: automatic and normal. Automatic mode enables automatic triggering in absence of a trigger event. This mode will wait the sweep time plus 40 ms before it auto triggers. Normal mode will wait indefinitely for a trigger event before capturing data. Sweep mode is configured using the *Sweep Mode Command.*

## Sweep Reference Scenarios

The ZT412 provides a flexible trigger to record timing adjustment that enables pre-trigger, post-trigger, or delayed trigger. The following figure depicts five sweep reference scenarios.



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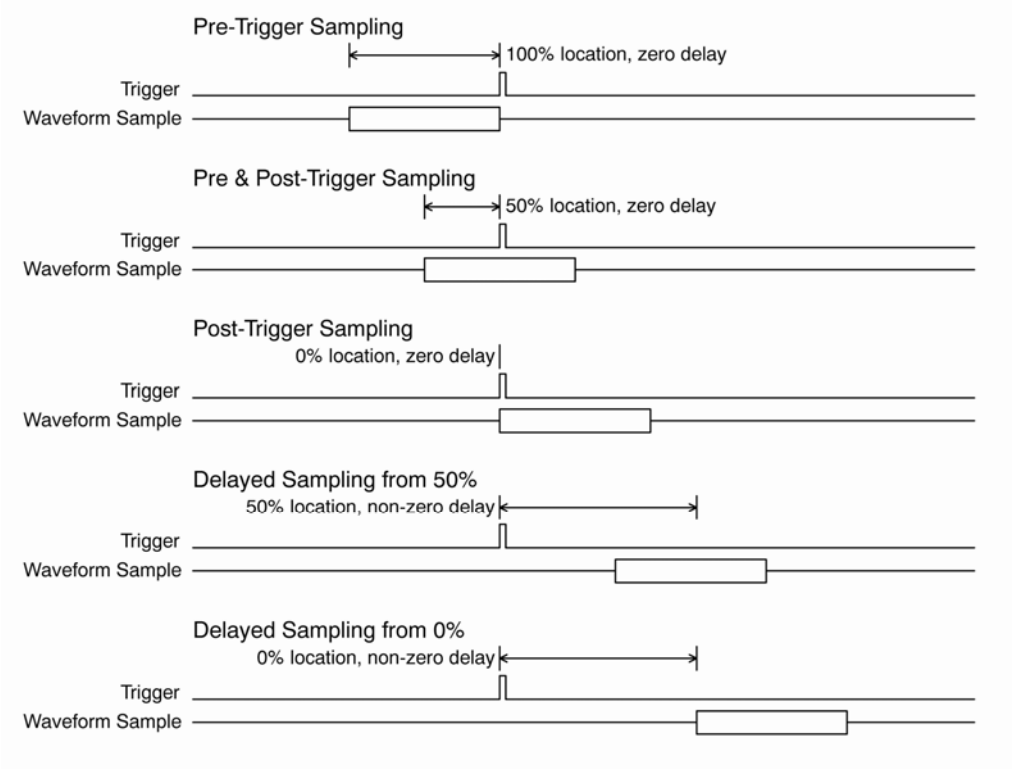



**Figure 5: ZT412 Sweep Reference Scenarios**

The trigger location within the waveform can be programmed between 0.0 (0%, start of waveform) and 1.0 (100%, end of waveform) using the *Sweep Offset Reference Command*. A timing delay between this reference location and the trigger event is also programmable using the *Sweep Offset Time Command*. This timing delay adjusts the trigger to a reference position in the positive time direction. Positive values move the end-of-capture further from the trigger event and consequently move the offset reference to the left. This allows the waveform capture to be delayed long after the trigger event.

The maximum cumulative delay between the trigger event and the end of the waveform record is 655 seconds. The cumulative delay is defined as:

**Cumulative delay = (1 – Sweep Offset Location * Sweep Time) + Sweep Offset Time**

**Note:** A trigger delay of 0.0 seconds causes the trigger position to be set by the offset reference location only, forcing the trigger to lie within the waveform.

# Averager Controls

The ZT412 Averager controls enable the instrument to acquire multiple waveforms to create the resulting waveform record.



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## Averager Considerations

The following are considerations of using the averager controls:

- When averaging is enabled on the ZT412, only the final output waveform is retained; the raw, un-averaged data is not available.
- When the average is disabled, (NORMAL acquisition mode), waveforms are passed through without modification.
- The number of waveforms averaged and the average operation mode can be selected (See the *Average Count Command* and *Average Type Command* respectively).
- When averaging is enabled, it affects all active input channels.

## Acquisition Types

There are four types of acquisition that can take place on the ZT412: Normal, Average, Envelope, and Equivalent-Time.

- In Normal mode, a single waveform is captured.
- In Scalar Average mode, waveform points from consecutive acquisitions are averaged together to produce the final displayed waveform. In Scalar Average mode, only two of the four inputs can be captured simultaneously. In Scalar Average mode, only one channel per channels 1-2 and one channel per channels 3-4 may be enabled.
- In Envelope mode, the minimum and maximum waveform points from multiple acquisitions are combined to form a waveform (an envelope) that shows minimum and maximum changes over time. In Envelope mode, only two of the four inputs can be captured simultaneously. In Envelope mode, only one channel per channels 1-2 and one channel per channels 3-4 may be enabled.
- In Equivalent-Time mode, a picture of a repetitive waveform is constructed by capturing a little bit of information from each repetition. This enables waveforms to be reconstructed at equivalent-time sample rates greater than the real-time sample rate (See Figure 6). Because the points appear randomly along the waveform, it is important to note that an entire waveform may not be constructed unless there are sufficient repetitions. Also, the number of points per point (selectable from 2 to 100) can be set to increase the resolution of the waveform. (See the *Average Equivalent Time Points Command*).



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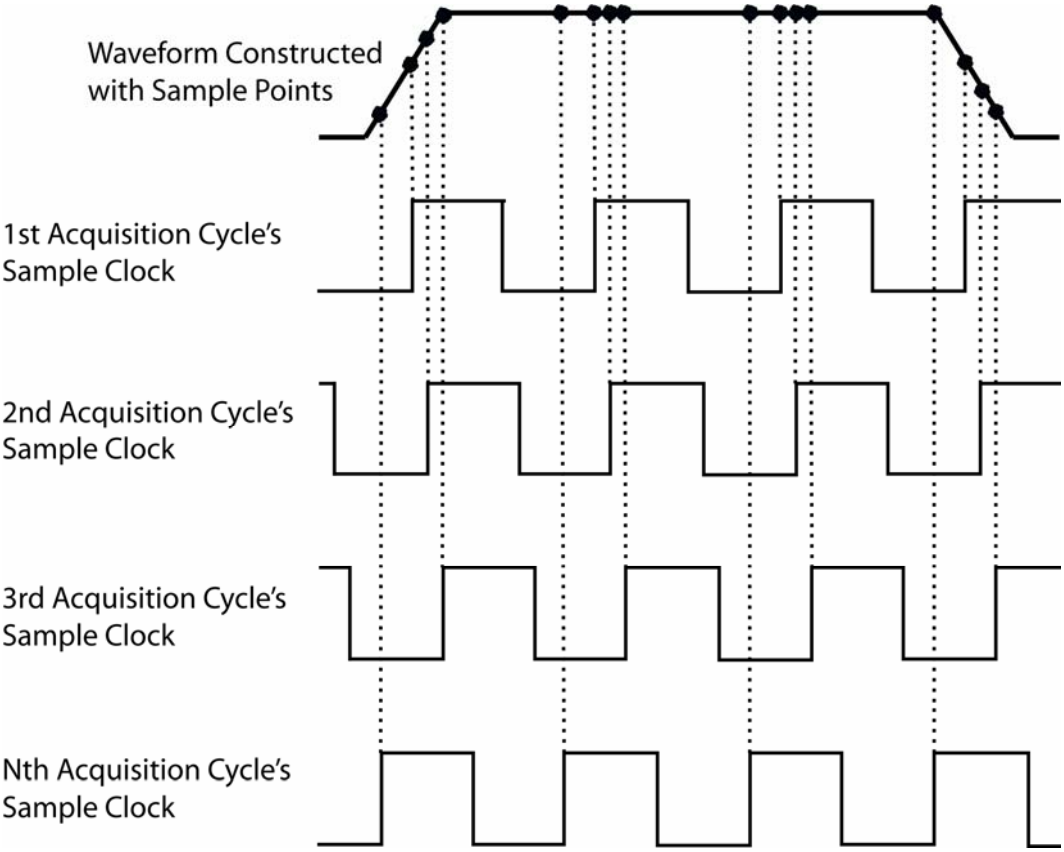



**Figure 6: Equivalent Time Acquisition**

# Trigger and Arm Controls

The trigger and arm controls stabilize repeating waveforms and allow capture of single-shot waveforms.

## Trigger Initiate Model

The ZT412 uses an arm-trigger model to control data acquisition. All acquisition cycles are started using the *Initiate Command*. Upon receiving an "initiate", the ZT412 will sequence into the "wait for arm" state. When the arm source goes active or if the arm source is set to immediate, the ZT412 will sequence into the "wait for trigger" state. When a trigger event is detected, the ZT412 will capture a waveform. The trigger loop will cycle for a selected number of times, saving the waveform associated with each pass. When the requested number of trigger loops has completed, the ZT412 will sequence back to the idle state. An *Abort Command* or *Reset Command* will immediately stop the capture sequence and return the instrument to the idle state from any other state.

The following figure shows a diagram of the trigger initiate model based on trigger mode. It shows the arm source, trigger source, and Initiate.



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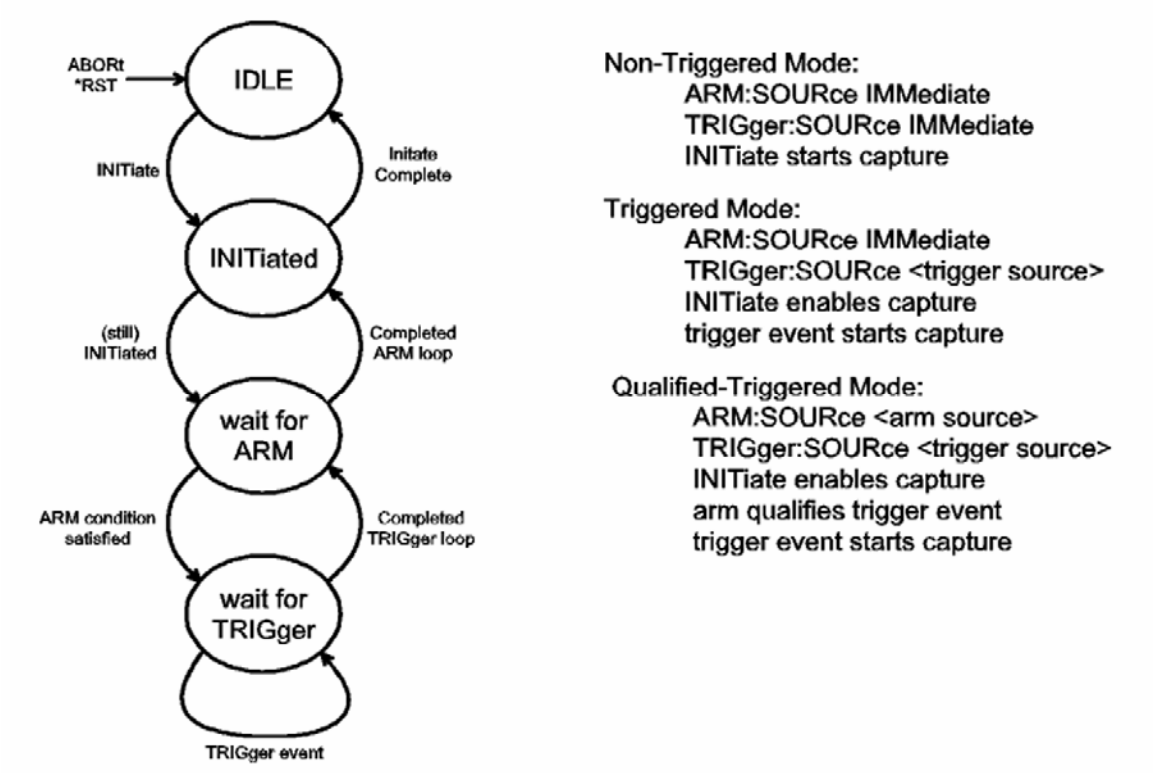



**Figure 7: Trigger Initiate Model**

## Trigger Processing

The ZT412 accepts triggers from the following sources:

- Channels 1 to 4 (BNC)
- External Trigger (BNC)
- External Arm (BNC)
- ECLTRG0-1
- TTLTRG0-7*
- Pattern
- Software



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Figure 8 shows a diagram of the ZT412 trigger processing.

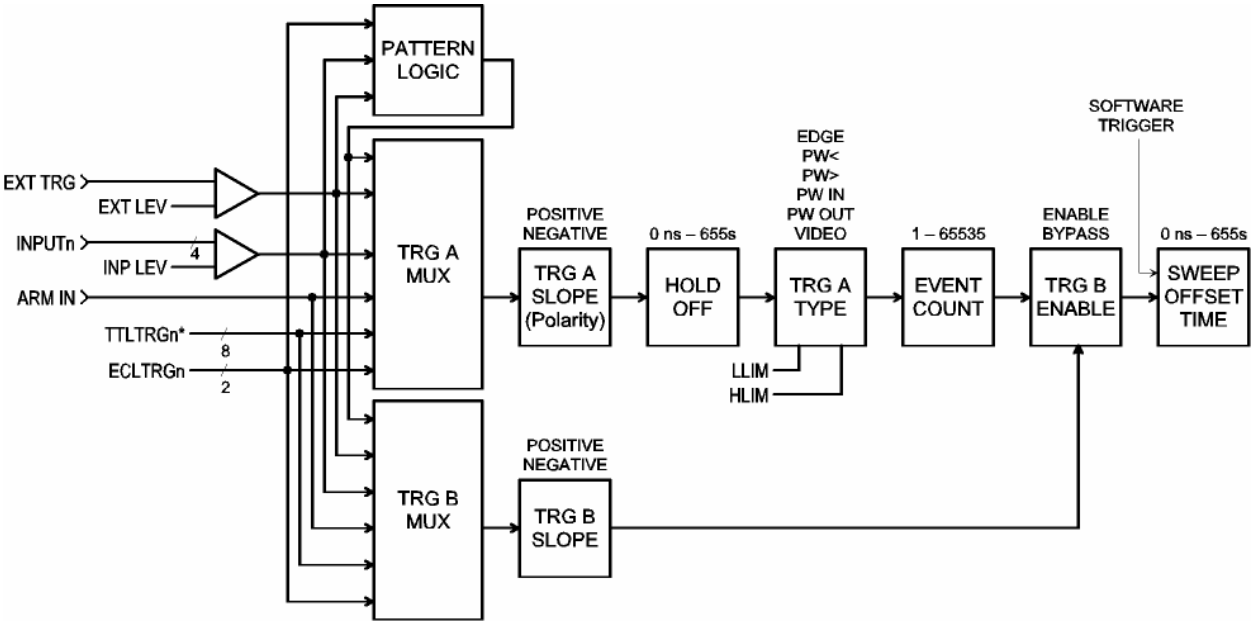



**Figure 8: Trigger Processing**

## Trigger Types

Several types of triggers are used with the ZT412, including software, edge, pulse width, pattern, video, and event. Each type of trigger uses a different configure trigger function.

### Software Trigger

Software triggers occur when a software command is used to force a trigger event to continue acquisition, regardless of the selected trigger source, type, or polarity. If manual (software) trigger source is selected, the software trigger must be used to cause a trigger event. An *Operation Complete Query* can not be used in conjunction with software triggering.

### Edge Trigger

An edge trigger occurs when a signal crosses a specified trigger threshold. Specify the slope as either positive (on the rising edge) or negative (on the falling edge) to the trigger. Edge triggering is possible on all trigger sources.

### Pulse Width Trigger

A pulse width trigger occurs when a signal triggers on a pulse width greater than a set limit, less than a set limit, between two set limits, or outside of two set limits. The pulse width range is 20 ns to 655 seconds with a resolution of 10 ns. Pulse width triggering is possible on all trigger sources.



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Pattern Trigger

A pattern trigger occurs when a set pattern is matched TRUE or FALSE. Sources for the pattern are Channels 1 to 4, External Trigger, External Arm, and ECLTRG0–1. The three states for a pattern match are HIGH, LOW, or DO NOT CARE. Trigger polarity affects pattern match (positive polarity) or pattern not match (negative polarity). For example, a pattern trigger could be set up to trigger only when Channel 1 is LOW, Channel 2 is HIGH, ECLTRG0 is LOW, and the External Trigger is HIGH.

Video Trigger

A video trigger occurs when the ZT412 finds valid video signal synchronization. The ZT412 includes a mode for triggering on NTSC (60 Hz), PAL (50 Hz), and SECAM (50 Hz) format video standards, as well as triggering on a specific video line number and a specific video field.

Event Trigger

An event trigger enables the counting of multiple trigger events before completion of each acquisition cycle. The ZT412 allows a range of 1 to 65535 trigger events, where each trigger event is qualified by the selected source, type, polarity, or slope.

Trigger B

Trigger B enables edge triggering on a second trigger source after all Trigger A conditions are satisfied. Trigger A detection must complete before the Trigger B detector or sweep offset timer.

## Arm

Each trigger must be qualified by an associated arm state condition. The arm polarity can be positive or negative. Arm sources include the following:

- External Arm input (BNC)
- External Trigger input (BNC)
- ECLTRG0–1
- TTLTRG0–7*
- Software

## Trigger Timestamp

The trigger timestamp captures the time of the trigger event. This timestamp has a one-second period with a 100 ns resolution. With timestamps, it is possible to correlate multiple records or even multiple acquisitions. For example, a timestamp can be used to determine the amount of time between acquisitions.



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# Outputs

## Trigger Outputs

The ZT412 can drive signals over any combination of the ten backplane trigger outputs (TTLTRG0–7* and ECLTRG0–1). Each output can be independently configured with unique source and enable controls.

Trigger Output sources include the following:

- Trigger event
- Arm event
- OPC event that occurs when all ZT412 operations are complete using the *Operation Complete Command*.
- Constant level (high or low)

## Reference Output

The ZT412 provides a multi-function front-panel reference output signal source, REF OUT. The reference output can be selected from the following sources:

- a precision +8V voltage reference
- a 500 Hz TTL probe compensation output
- the selected 10 MHz TTL reference oscillator output
- the TTL Trigger event
- the TTL Arm event
- a 10 ns TTL pulse at 1 ms repetition interval
- a constant TTL low signal (reference output disabled)

# Calculate Controls

The ZT412 can create new waveforms mathematically. The unit has two calculate channels, each capable of a 32K maximum waveform size. Sources include the following:

- 4 Input Channels
- 4 Reference Channels
- 2 Calculation Channels

Calculations are processed in channel order (i.e. Calculation Channel 1 can act on Calculation Channel 1, Calculation Channel 2 can act on Calculation Channel 2, or Calculation Channel 2 can act on Calculation Channel 1). Examples of calculations include:

- Filter Measurements (Time Domain Transform)
- Two Channel Measurements
- Math Measurements
- FFT Measurements (Frequency Domain Transform)
- Limit and Mask Testing



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## Calculate Functions

The following are the calculate functions:

Add

Use the *Calculate Add Command* to add the waveforms from the two sources.

Subtract

Use the *Calculate Subtract Command* to subtract the waveform from one source from the other source.

Multiply

Use the *Calculate Multiply Command* to multiply the waveforms from the two sources.

Copy

Use the *Calculate Copy Command* to copy the waveform from the source to the calculation channel.

Invert

Use the *Calculate Invert Command* to invert the source waveform.

Integral

Use the *Calculate Integral Command* to calculate the integral of the source waveform and place the result into its output.

Derivative

Use the *Calculate Derivative Command* to create a waveform that shows the rate of change of the source waveform. The derivative equation is:

$$y(i) = \frac{x(i) - x(i-1)}{\triangle t}$$

Absolute Value

Absolute value establishes an absolute value of the source waveform. All negative values are converted to positive.

Limit Test

This conducts a limit test on the waveform (See Chapter 4 for all of the limit test commands). Limit testing is the ability to compare an active signal with user-defined vertical and horizontal tolerances (test conditions) applied to measurements. Test conditions are established and an



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*Initiate Continuous Command* is given to initiate the waveform continuously. If the active waveform exceeds the test conditions, it is a failure and the following actions occur:

- The waveform is stored into memory
- Measurement statistics are recorded including the Minimum, Maximum, Average, Failure Count, Total Count, and the Most Recent Measurement.
- The test may be stopped or run continuously.

**Note:** Do not perform a limit test where the calculation source and destination use the same calculation channel.

Mask Test

This conducts a mask test on a waveform (See Chapter 4 for all of the mask test commands).

A mask test is a type of limit test performed point-by-point on a waveform, determining whether an acquired signal meets a given set of criteria. It consists of an upper boundary (Ref_Max) and lower boundary (Ref_Min) where the captured waveform must not cross. These masks are typically defined by industry standards or user-defined limits, but both the references and the waveform must be the same length. The signal is first captured by the unit and then compared to the limit mask to verify whether it falls between the given limits. If any part of the waveform falls outside the mask, the software counts a failure.

**Note:** Do not perform a mask test where the calculation source and destination use the same calculation channel.

Frequency Transform

This conducts a Fast Fourier Transform (FFT) on a waveform (Use the *Calculate Transform Frequency Command* and the *Calculate Transform Frequency Window Command*).

The Fast Fourier Transform process mathematically converts the standard time-domain signal into its frequency components, thus providing spectrum analysis capabilities. Being able to quickly look at the signal frequency components and spectrum shape is a powerful research and analysis tool. FFT is an excellent troubleshooting aid for:

- Testing impulse response of filters and systems
- Measuring harmonic content and distortion in systems
- Identifying and locating noise and interference sources
- Analyzing vibration
- Analyzing harmonics in 50 and 60 Hz power lines

FFT results in power spectrum data in units of RMS voltage ($V_{RMS}$) represented as signed 16-bit values. The sample size is always a power of 2 ($2^N$). The following table shows the sample range, FFT size, and approximate computation time:



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| Sample Range | FFT Size | Approximate Computation Time in seconds |
|---|---|---|
| 100–128 | 64 | 0.01s |
| 129–256 | 128 | 0.02s |
| 257–512 | 256 | 0.03s |
| 513–1024 | 512 | 0.06s |
| 1025–2048 | 1024 | 0.12s |
| 2049–4096 | 2048 | 0.25s |
| 4097–8192 | 4096 | 0.53s |
| 8193–16384 | 8192 | 1.13s |
| 16385–32768 | 16384 | 2.35s |

**Table 5: FFT Sample Range and Size**

Four FFT windows (Rectangular, Hamming, Hanning, and Blackman) are available to match an analyzed signal. The Rectangular window is the best choice for non-periodic events such as transients, pulses, and one-shot acquisitions. The Hamming, Hanning, and Blackman windows are better choices for periodic signals. The following table provides a comparison of the four window types.

| FFT Window | Characteristics | Used For |
|---|---|---|
| Rectangular | Best frequency, worst magnitude resolution. This is essentially the same as no window. | • Transients or bursts where the signal levels before and after the event are nearly equal<br>• Equal-amplitude sine waves with frequencies that are very close<br>• Broadband random noise with a relatively slow varying spectrum |
| Blackman | Best magnitude, worst at resolving frequencies | • Single frequency waveforms to look for higher order harmonics |
| Hamming | Better frequency, poorer magnitude resolution than Rectangular. Slightly better frequency resolution than Hanning. | • Sine, periodic, and narrowband random noise.<br>• Transients or bursts where the signal levels before and after the event are significantly different |
| Hanning | Better frequency, poorer magnitude resolution than Rectangular. | • Sine, periodic, and narrowband random noise.<br>• Transients or bursts where the signal levels before and after the event are significantly different |

**Table 6: FFT Window Comparison**



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Time Domain Transform

This conducts a low-pass filter Time Transform on a waveform (Use the *Calculate Transform Time Command*). The number of filter length data points (Range of 2 to 40) used to calculate the Time Transform is set in the second-order Infinite Impulse Response (IIR) filter (*Use the Calculate Transform Time Points Command*). A higher filter length point number causes a lower cutoff frequency for the filter.

# Measure Controls

Waveform measurements offer a method for returning scalar measurement data from the ZT412 instead of the multi-point waveforms. The instrument can process a time-domain or frequency-domain waveform, and return many types of scalar measurement results.

## Time Domain Measurements

The following list describes the measurements that can be performed upon time-domain waveforms:

| | |
|---|---|
| Average | Average value of the entire captured waveform. |
| Alternating Current (AC) | The AC RMS characteristic of the signal subtracts the DC Average before computing the RMS. |
| AC High-Precision | The AC RMS level of the signal with more precision for use with waveform records having more than 8-bit resolution, such as averaged waveforms. The added precision requires approximately 10X processing time. The added precision is most noticeable when there is a non-zero input offset setting. |
| Amplitude | The low-to-high voltage amplitude of the applied signal. |
| Cycle Average | The average level of the first cycle of the selected waveform source. |
| Cycle Frequency | The frequency of the first cycle of the waveform. |
| Cycle Period | The period of the first cycle of the waveform. |
| Cycle RMS | The AC voltage RMS for one cycle of the waveform, measured from mid-point to mid-point. |
| Direct Current (DC) | The DC RMS level of the signal. |
| DC High-Precision | The DC RMS level of the signal with more precision for use with waveform records having more than 8-bit resolution, such as averaged waveforms. The added precision requires approximately 10X processing time. The added |



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| | |
|---|---|
| | precision is most noticeable when there is a non-zero input offset setting. |
| Fall Crossing Time | The time of the selected falling edge of a waveform crossing the middle reference threshold measured from the start of the waveform. The edge number is selectable. |
| Fall Overshoot | The difference between the low level and the negative peak level of a signal as it transitions from its high state to its low state, expressed as a ratio of waveform amplitude. |
| Fall Preshoot | The difference between the high level and the maximum level of a signal as it transitions from its high state to its low state, expressed as a ratio of the waveform amplitude. |
| Fall Time | The time it takes the falling edge of a pulse to go from the upper reference threshold to the lower reference threshold. |
| Frequency | The frequency of the signal. All cycles in the entire capture window are used. |
| High | The high signal level. |
| Low | The low signal level. |
| Maximum | The maximum value of the waveform. |
| Minimum | The minimum value of the waveform. |
| Negative Duty Cycle | The ratio of negative width to period. |
| Negative Width | The negative width is expressed in seconds from the first falling edge reference to the next rising edge reference. The same reference is used for the rising and falling edges. The threshold is defined as the mid voltage level, or midway between high and low levels. |
| Peak-To-Peak | The peak-to-peak voltage or maximum to minimum voltage of the signal. |
| Period | Measures the period of the signal (1/frequency) using all cycles in the entire capture window. |
| Phase | Measures the phase of a periodic signal at the start of the Waveform in radians. |
| Positive Duty Cycle | The ratio of positive width to period. |
| Positive Width | The positive width expressed in seconds from the first rising edge reference to the next falling edge reference. The same reference is used for the rising and falling |



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| | |
|---|---|
| | edges. The threshold is defined as the mid voltage level, or midway between high and low levels. |
| Rise Crossing Time | The time of the rising edge of a waveform as it crosses the middle reference threshold measured from the start of the waveform. The edge number is selectable. |
| Rise Overshoot | The difference between the high level and the positive peak level of a signal as it transitions from its low state to its high state, expressed as a ratio of waveform amplitude. |
| Rise Preshoot | The difference between the low level and the negative peak level of a signal as it transitions from its low state to its high state, expressed as a ratio of the waveform amplitude. |
| Rise Time | Measures the time for the leading edge of a pulse to rise from its lower reference threshold to its upper reference threshold. The edge number is selectable. |
| Time of Minimum | The time at which the first occurrence of the minimum voltage occurs. |
| Time of Maximum | The time at which the first occurrence of the maximum voltage occurs. |

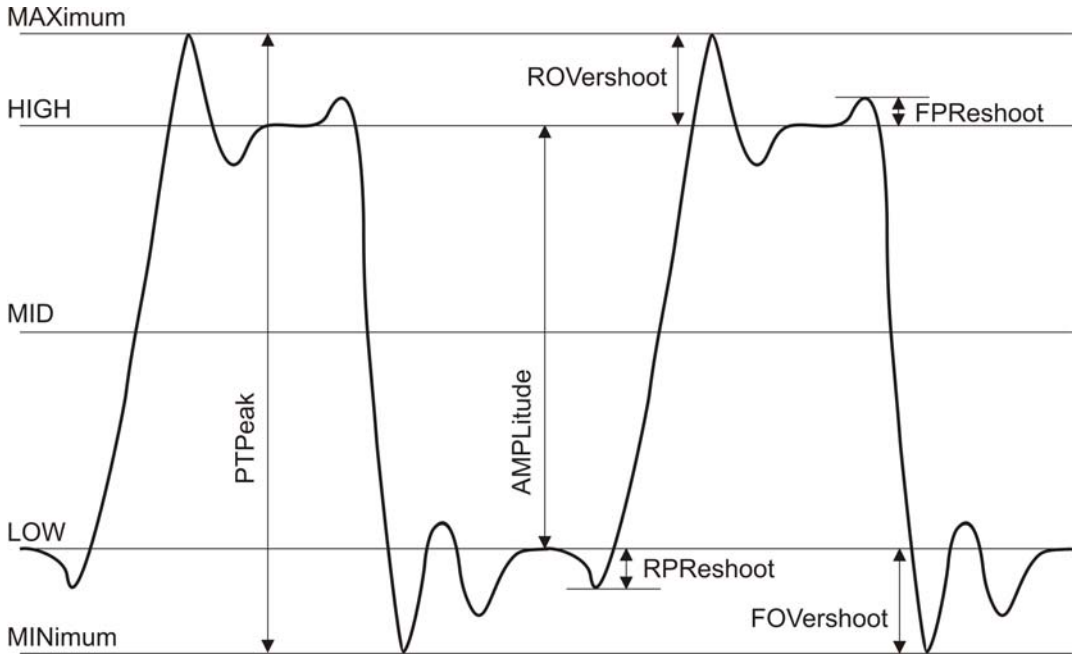



**Figure 9: Vertical-Axis Measurement Terminology**



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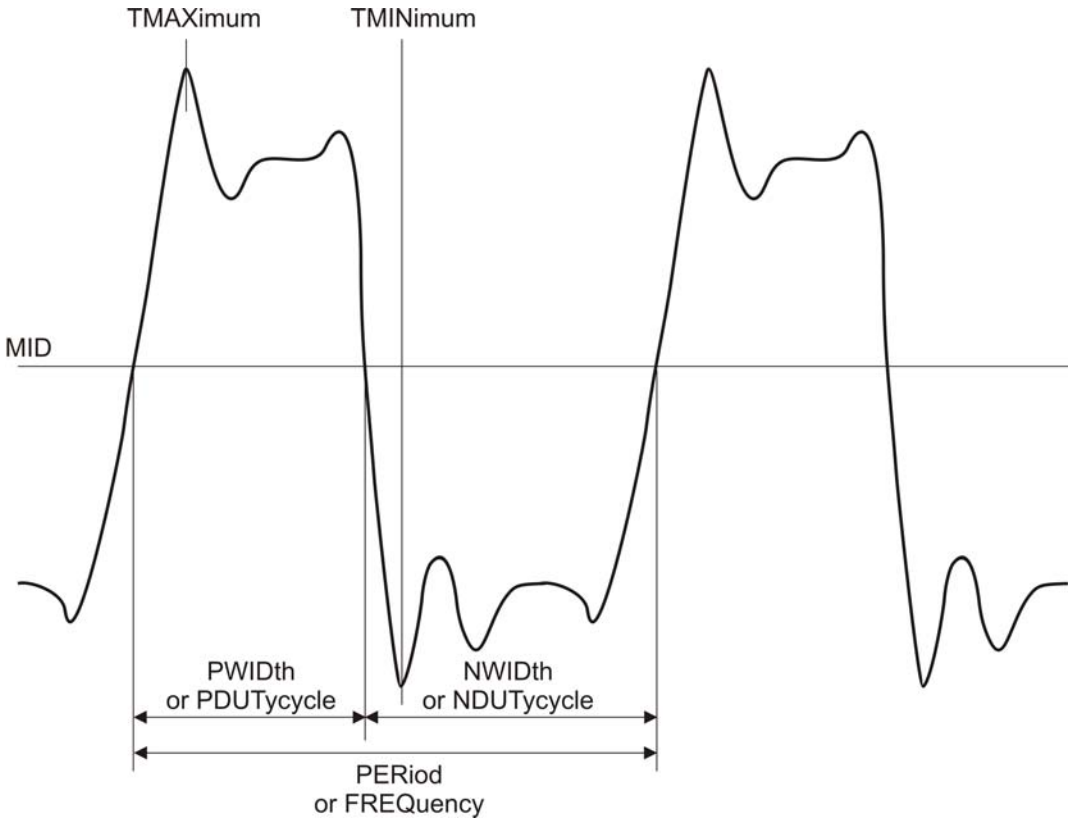



**Figure 10: Horizontal-Axis Measurement Terminology**

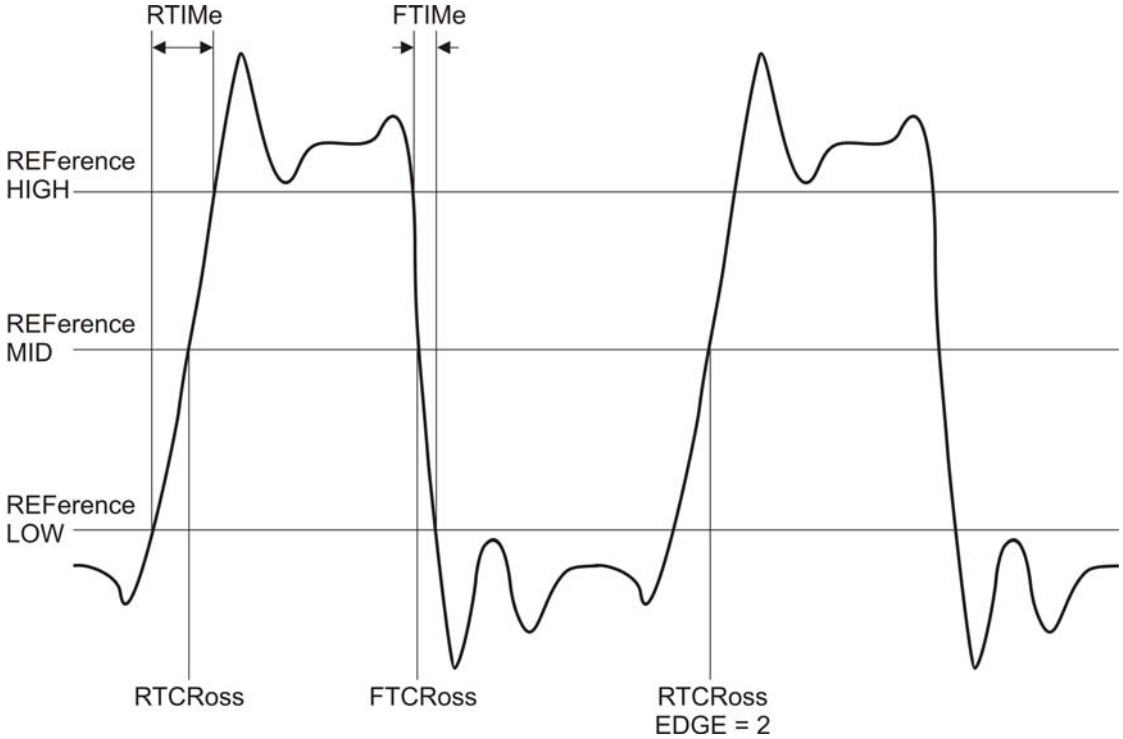



**Figure 11: Edge Measurement Terminology**



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## Frequency-Domain Measurements

Figure 12shows an example of frequency-domain measurement terminology. The following describes the measurements that can be performed upon frequency-domain waveforms, such as an FFT waveform in a calculate channel:

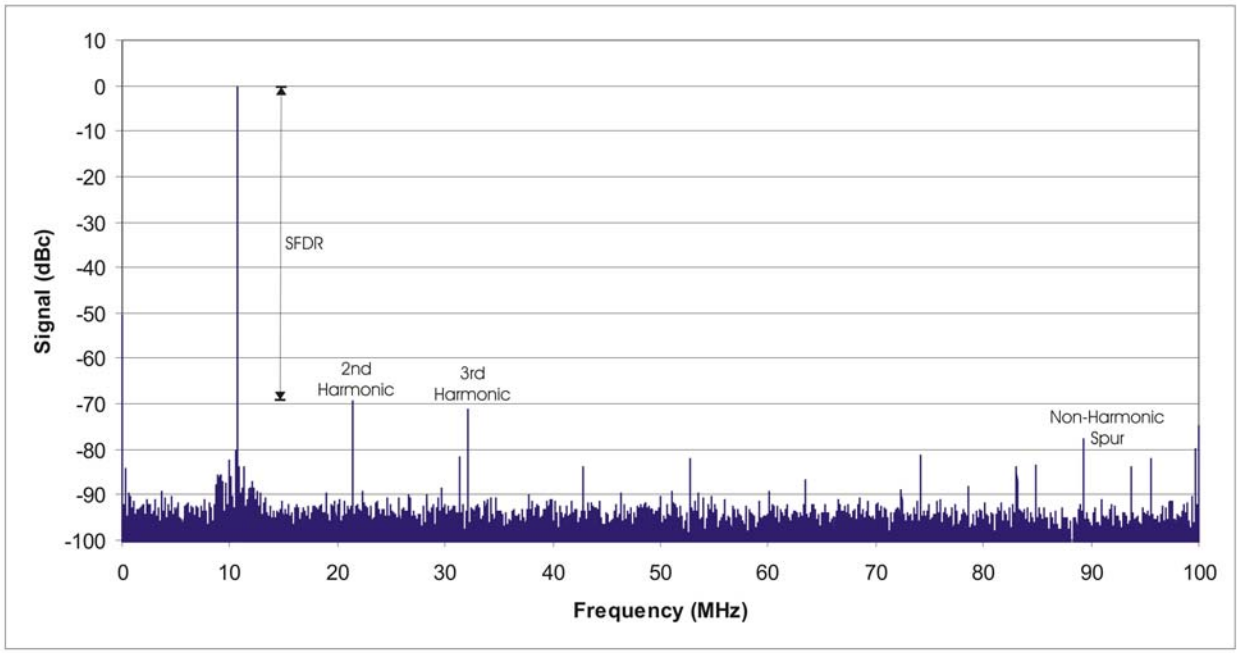



**Figure 12: Frequency-Domain Measurement Terminology**

| | |
|---|---|
| Signal-to-Noise Ratio | Signal-to-Noise Ratio (SNR) is the ratio of the RMS amplitude of the input signal fundamental to the RMS amplitude of the sum of all non-harmonic noise sources. The input signal is assumed to be a perfect single-frequency sinusoidal signal. All signal components other than the input signal fundamental are considered to be harmonic distortion or noise. SNR does NOT include the first nine (second through tenth-order) harmonics as noise. This measurement is expressed in decibels relative to carrier (dBc) and is a positive value. |
| Total Harmonic Distortion | Total Harmonic Distortion (THD) is the ratio of the RMS amplitude of the sum of the first nine (second through tenth-order) harmonics to the RMS amplitude of the input signal fundamental. The input signal is assumed to be a perfect single-frequency sinusoidal signal. All signal components other than the input signal fundamental are considered to be harmonic distortion or noise. This measurement is expressed in decibels relative to carrier (dBc) and is a negative value. |



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| | |
|---|---|
| Spurious-Free Dynamic Range | Spurious-Free Dynamic Range (SFDR) is the ratio of the RMS amplitude of the input signal fundamental to the RMS amplitude of the largest spurious signal. The spurious signal can be either a harmonic or non-harmonic of the input signal fundamental. The input signal is assumed to be a perfect single-frequency sinusoidal signal. All signal components other than the input signal fundamental are considered to be spurious signals. This measurement is expressed in decibels relative to carrier (dBc) and is a positive value. |
| Signal-to-Noise and Distortion | Signal-to-Noise and Distortion Ratio (SINAD) is the ratio of the RMS amplitude of the input signal fundamental to the RMS amplitude of the sum of all noise and distortion sources. The input signal is assumed to be a perfect single-frequency sinusoidal signal. All signal components other than the input signal fundamental are considered to be harmonic distortion or noise. SINAD is equivalent to the RMS sum of SNR and THD. This measurement is expressed in decibels relative to carrier (dBc) and is a positive value. |
| Effective Number of Bits | Effective Number of Bits (ENOB) provides a measure of the input signal dynamic range as if the signal were converted with an ideal analog-to-digital converter (ADC). ENOB provides the number of bits of an ideal ADC that would result in quantization noise equivalent to the sum of all input signal noise and distortion sources. ENOB is directly related to SINAD by the following equation:<br>ENOB = (SINAD – 1.763) / 6.02<br>This measurement is expressed in bits and is a positive value. |

## Invalid Measurements

The ZT412 returns an invalid measurement code (9.99999E+37) whenever it encounters an invalid measurement condition. The following describes types of invalid measurement conditions.

Voltage Measurements

Voltage measurements (such as *Measure High Voltage Query*) where there is an over-voltage condition with the applied voltage exceeding the input range of the ADC will return the invalid measurement code (See Figure 13.



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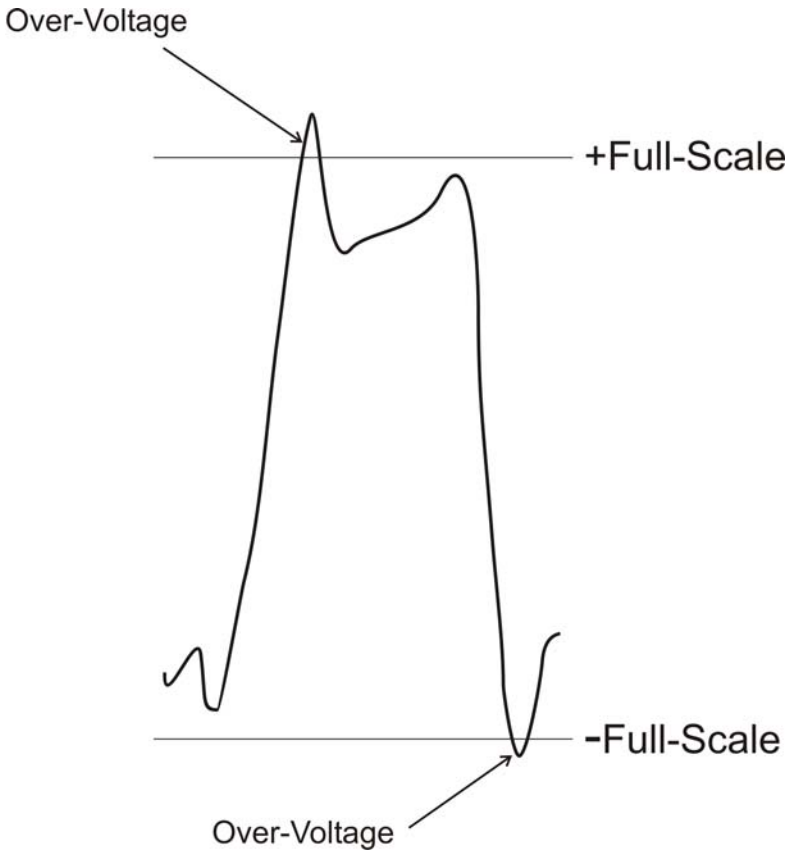



**Figure 13: Invalid Voltage Measurements**

RMS Measurements

The ZT412 will always return the measured value for an RMS measurement, even if a signal is clipped (over-voltage).

Cycle and Width Measurements

Cycle measurements (such as *Measure Period Query* or *Measure Frequency Query*) require at least three mid-point crossings in the capture window. Width measurements (such as *Measure Positive Width Query* or *Measure Positive Duty Cycle Query*) use at least two mid-point crossings in the capture window. If the required number of mid-point crossings is not found, the ZT412 will return the invalid measurement code.

Edge Measurements

Rising and falling edge measurements (such as *Measure Rise Time Query*) require at least as many edges present in the capture window as the user-requested edge number. An edge crossing is defined as a voltage crossing of the middle reference level. If the requested edge is greater than the number of edges in the capture window (3 or greater for a rising edge measurement on the waveform in Figure 14, the ZT410 will return the invalid measurement code. Also, an invalid measurement code will be returned if, although the requested edge is found, a complete edge is not captured and is required to make the measurement.



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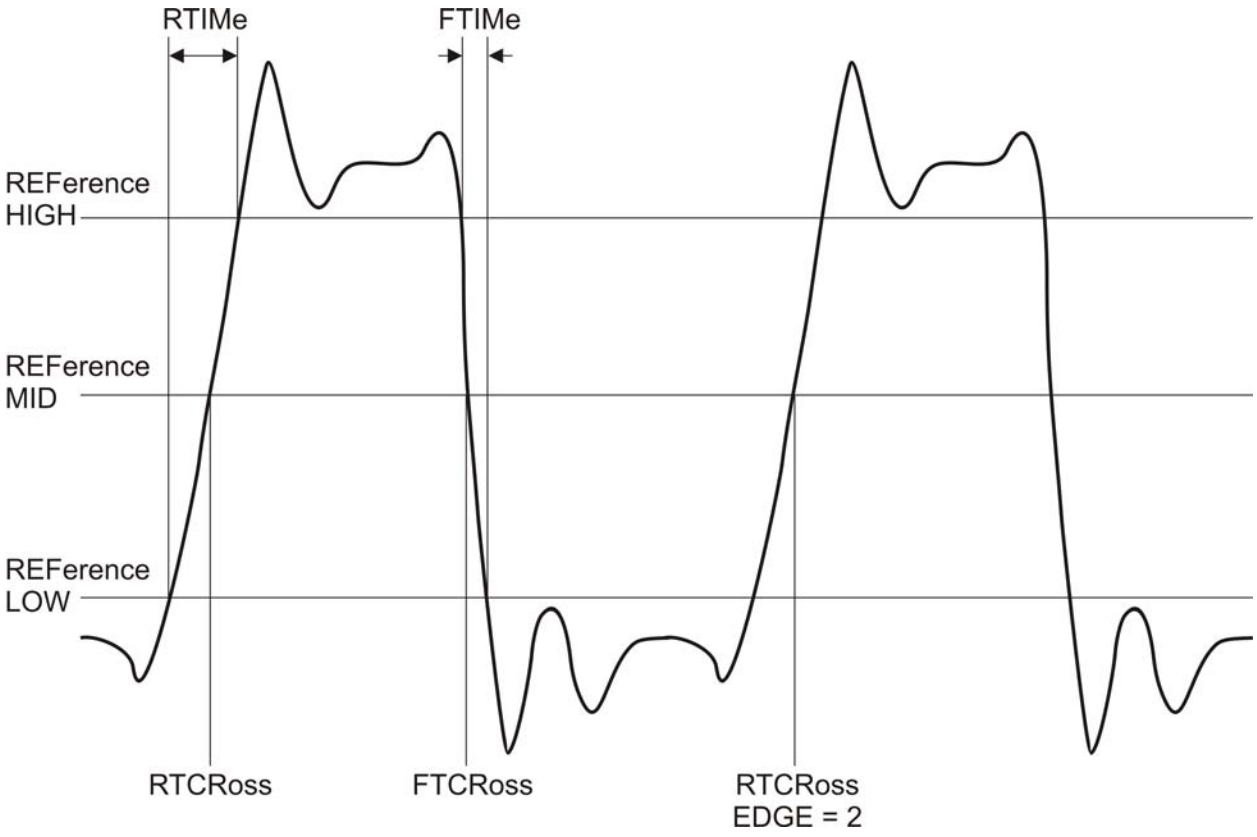



**Figure 14: Invalid Edge Measurements**

Frequency-Domain Measurements

The ZT412 will return an invalid measurement code if the input sinusoidal fundamental cannot be resolved from the noise level. The invalid measurement code will also be returned if a frequency-domain measurement is attempted upon a non-frequency domain waveform, as identified by the waveform preamble header.

## Measurement Method

The following measurement methods are available on the ZT412: Entire Waveform, Gated by Time, and Gated by Points.

Entire Waveform

Entire Waveform measurement performs measurements on the entire captured waveform.

Gated by Time

Gated by Time measurement performs measurements on a waveform where the user defines a start time and stop time. “0” represents the start of the waveform.



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Gated by Points

Gated by Points measurement performs measurements on a waveform where the user defines a start point and stop point. “0” represents the start of the waveform.

### Measurement Reference Levels

Measurement reference levels are high, low, and mid range values that are set to take rise time, fall time, fall crossing time, and rise crossing time measurements. Reference levels are configured in relative terms of the percentage of the waveform acquired, or in absolute voltage levels. By default, the low value is 10 percent of the waveform, the mid level is 50 percent, and the high value is 90 percent.

Reference levels are user-defined using the *Measure Reference Command* and *Measure Reference Method Command*. Levels are set by percent or volts as follows:

- Low reference selects the threshold for detection of the input signal low state.
- Middle reference selects the threshold for detection of the input signal middle level.
- High reference selects the threshold for detection of the input signal high state.
- Relative reference values range from 0.0 (0 percent) to 1.0 (100 percent).
- Absolute reference values are expressed in volts.

### Measurement Edge

The measurement edge is the waveform edge used in edge-related measurements (See *Measure Edge Command*). Select a falling or rising edge using a 16-bit unsigned integer value. A measurement edge is used in the following measurement types: rise time, rise crossing time, rise overshoot, rise preshoot, fall time, fall crossing time, fall preshoot, and fall overshoot.

## Waveform and Reference

### Read Waveform

The ZT412 uses a shared VXI memory to report acquisition results to the VXI host processor. Because the shared memory is smaller than most waveform records, a typical waveform download will require that the waveform be read in blocks multiple times and the data be appended together to form the final output. A waveform consists of signed 16-bit values.

### Read Waveform Preamble

The preamble provides information necessary to convert the 16-bit integer waveform samples to and from time and voltage values. Preamble information is divided into three blocks: header information, time axis information, and voltage information as described below:



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Header Information

- Waveform Type:
  - 0 = Invalid waveform
  - 1 = Normal voltage-time waveform
  - 2 = Averaged voltage-time waveform
  - 3 = Envelope waveform
  - 4 = Equivalent Time waveform
  - 16 = Frequency Domain Waveform (FFT)

- Count: The number of acquisitions processed to produce an output average, envelope, or equivalent time waveform.

- Size: The number of samples in the sample record.

Time Axis Information

- Increment: The time interval between samples
- Offset: Time between the trigger event and the first sample in the sample record

**Note:** For FFT waveforms, the X-axis displays the frequency in Hertz.

Voltage Axis Information

- Increment: The voltage interval of 1 Least Significant Bit (LSB).
- Offset: The voltage offset represented by the sample "0" code

To recreate a waveform from the preamble and sample record, use the following relationships:

- Sample Time = time offset + (sample number * time increment)
- Sample Voltage = voltage offset + (sample code value * voltage increment)

## Reference Waveform

The ZT412 can save and download up to 4 reference waveforms. The reference waveforms, REF1–4, are stored in non-volatile Flash memory and are maintained when the unit is powered off. These waveforms are limited to record sizes of 32 kSamples.

- Store: copied from input, calculate and reference sources.
- Load: loaded as codes from VXI host (load preamble when loading waveform).

# Utilities and Status Reporting

## Auto Scale

The ZT412 can automatically adjust input signal settings. The following are the adjustable parameters for all enabled input channels:

- Input Range



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- Offset
- Points (Automatically sets the number of points to 1,000)
- Sample Rate (Selected for the signal with the largest amplitude)
- Trigger Source (Selected for the signal with the largest amplitude)
- Trigger Level (Selected for the signal with the largest amplitude)

## Reset and Device Clear

Use the *Reset Command* to perform a hard reset of the ZT412. This stops all acquisition and configures the unit to its default state. See *Appendix 2, Default Reset Conditions,* for a listing of all ZT412 default conditions.

## Save and Recall States

The ZT412 can save and recall up to 31 instrument configuration states. These states record the input settings, horizontal sweep settings, trigger settings, and capture settings. The current instrument state can be saved and recalled later. All states are stored in non-volatile Flash memory and are maintained when the unit is powered off. The *Reset Command*, *Save Instrument State Command*, and *Recall Instrument State Command* control the instrument state configuration.

## Error

There is a capability to see any and all system errors. The *System Error All Query* returns all 32 entries in the error log and clears the error log. Multiple errors are stored sequentially in the error log with the oldest error first. A zero value is returned for all non-error entries when there are less than 32 errors stored in the error log. The *System Error Count Query* returns the number of errors in the error log. The *System Error Query* returns and clears the first entry in the error log. See *Appendix 3, System Error Codes*, for a list of error codes.

## Status

The status register structure provides a common way to perform status reporting according to the IEEE 488.2 specification. This status register structure allows the user to examine the conditions of the following subsystems on the ZT412: Voltage, Frequency, Calibration, Self-Test, Questionable, Operation, and Standard Event.

Each status data register set contains a condition register, an event register, and an event enable register. The summary output of a status data register set may be used to propagate the status summary to the next status level, and ultimately to the Status Byte. Figure 17 shows the complete status register structure for the ZT412. Each individual status data register set contains the following registers with the following functionality:

Condition

A condition register provides the current device condition or state. The condition register reflects the TRUE or FALSE states in its condition bits, may range in length from 1 to 16 bits, and may contain unused bits. Unused bits will return a zero (0) value when read.



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**Note:** Reading a condition register does not change its contents.

Event

An event register captures changes in the associated condition register. Each event bit in an event register corresponds to a condition bit in a condition register. Event registers range in length from 1 to 16 bits and may contain unused bits. Unused bits will return a zero (0) when the register is read.

An event becomes TRUE when the associated device condition transitions to a TRUE state. The event register guarantees that the application cannot miss a condition that is removed before the condition register can be read. An event register bit will be set TRUE when an associated event occurs. These bits, once set, cannot be cleared even if they do not reflect the current status of a related condition, until the event register is read by the application. Also, the ZT412 provides a command to clear all event registers.

**Note:** Event bits are cleared when read.

Enable

An enable register selects which event bits in the corresponding event register will cause a TRUE summary output when an event occurs. The summary output enabled by the event enable register is used to propagate the status summary to the next status level. Each event bit in the event register has a corresponding enable bit in the event enable register. When an event enable bit is TRUE, the corresponding event will propagate to the status summary output. Any unused bits in the event enable register correspond with unused bits in the event register. The value of unused bits is zero (0) when the event enable register is read and is ignored when written to by commands.



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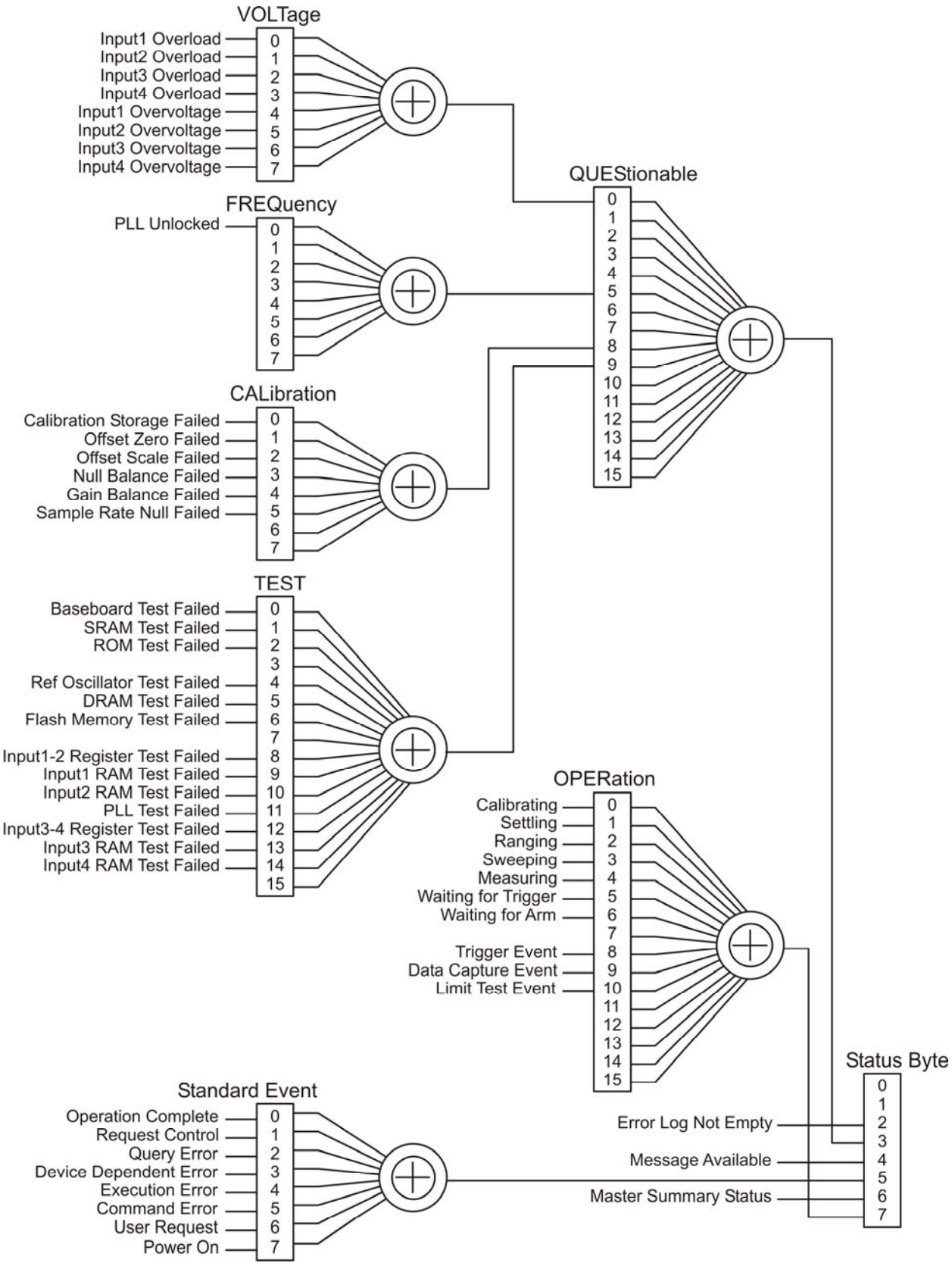



**Figure 15: Status Register**



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Status Commands and Queries

The device status of the ZT412 can be viewed at any time using any of the following commands or queries:

**Note:** See the appropriate command and query syntax in Chapter 4.

| Command or Query | Response |
|---|---|
| Clear Status Command | Clears all event status registers and the error log. |
| Event Status Enable Command | Sets the state of the event status enable register. The event status enable register allows the enabled standard events to affect the event summary status bit within the status byte. |
| Event Status Enable Query | Returns the state of the event status enable register. The event status enable register allows the enabled standard events to affect the event summary status bit within the status byte. |
| Event Status Query | Returns the status bits for the standard event status register. |
| Service Request Enable Command | Sets the state of the service request enable register. The service request enable register allows the enabled status byte events to affect the service request summary bits with the status byte. |
| Service Request Enable Query | Returns the state of the service request enable register. The service request enable register allows the enabled status byte events to affect the service request summary bits with the status byte. |
| Status Byte Query | Returns the Status Byte code. |
| Status Calibration Condition Query | Returns the current condition of the questionable calibration status register. |
| Status Calibration Enable Command | Allows the user to enable or disable the bits in the questionable calibration status register. The parameter is a bit mask which enables the corresponding questionable calibration status register bits. |
| Status Calibration Enable Query | Returns the bit mask of the questionable calibration status enable register. |
| Status Calibration Event Query | Returns the latched event state for the questionable calibration status register. |
| Status Frequency Condition Query | Returns the current condition of the questionable frequency status register. |



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| Command or Query | Response |
|---|---|
| Status Frequency Enable Command | Allows the user to enable or disable the bits in the questionable frequency status register. The parameter is a bit mask which enables the corresponding questionable frequency status register bits. |
| Status Frequency Enable Query | Returns the bit mask of the questionable frequency status enable register. |
| Status Frequency Event Query | Returns the latched event state for the questionable frequency status register. |
| Status Operation Condition Query | Returns the present condition of the operation status register. |
| Status Operation Enable Command | Sets the contents of the operation status enable register. The parameter is a bit mask which enables the corresponding operation status register bits. |
| Status Operation Enable Query | Returns the bit mask of the operation status enable register. |
| Status Operation Event Query | Returns the latched event state for the operation status register. |
| Status Preset Command | Sets the enable register to all 1s. For the mandatory status data structures, it sets the enable register to 0s. Also, it sets the error/event queue enabling to report only errors. |
| Status Questionable Condition Query | Returns the present condition for the questionable status register. |
| Status Questionable Enable Command | Allows the user to enable or disable the bits in the questionable status register. The parameter is a bit mask which enables the corresponding questionable status register bits. |
| Status Questionable Enable Query | Returns the bit mask of the questionable status register. That is, it returns a bit mask that indicates which questionable status register bits are enabled. |
| Status Questionable Event Query | Returns the latched event state for the Questionable Status Register. |
| Status Test Condition Query | Returns the present condition of the questionable test status register. |
| Status Test Enable Command | Allows users to Enable or Disable bits in the questionable test status register. The parameter is a bit mask which enables the corresponding questionable test status register bits. |
| Status Test Enable Query | Returns the bit mask of the Questionable Test Status |



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| Command or Query | Response |
|---|---|
| | Enable Register. That is, it returns a bit mask that indicates which Questionable Test Status Register bits are enabled. |
| Status Test Event Query | Returns the latched event state for the questionable test status register. |
| Status Voltage Condition Query | Returns the current condition of the questionable voltage status register. |
| Status Voltage Enable Command | Sets the contents of the voltage status enable register. The parameter is a bit mask which enables the corresponding questionable voltage status register bits. |
| Status Voltage Enable Query | Returns the bit mask of the questionable voltage enable register. |
| Status Voltage Event Query | Returns the latched event state for the questionable voltage status register. |

**Table 7: System Status**



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## Self Test

The ZT412 can initiate an instrument self test and return any test error results as a 16-bit code (See *Test Query*). The self test is initiated on instrument power up and returns:

| Hex Number Code | Error Type |
|---|---|
| $0001_{16}$ | Baseboard Test Failed Bit |
| $0002_{16}$ | SRAM Test Failed Bit |
| $0004_{16}$ | ROM Test Failed Bit |
| $0008_{16}$ | Unused Bits |
| $0010_{16}$ | Reference Oscillator Test Failed Bit |
| $0020_{16}$ | DRAM Test Failed |
| $0040_{16}$ | Flash Memory Test Failed Bit |
| $0080_{16}$ | Unused Bits |
| $0100_{16}$ | Input 1–2 Register Test Failed Bit |
| $0200_{16}$ | Input 1 RAM Test Failed Bit |
| $0400_{16}$ | Input 2 RAM Test Failed Bit |
| $0800_{16}$ | PLL Test Failed |
| $1000_{16}$ | Input 3–4 Register Test Failed Bit |
| $2000_{16}$ | Input 3 RAM Test Failed Bit |
| $4000_{16}$ | Input 4 RAM Test Failed Bit |
| $8000_{16}$ | Unused Bits |

**Table 8: Self-Test Errors**

## Calibrate

The ZT412 can perform an automatic, internal self-calibration upon command. The internal calibration determines the zero DC offset, the DC offset adjust scale factor, and the ADC balance for all input range settings for both input channels. Note that the external cables should be removed or 0.0 VDC should be applied to both input channels before commanding a self-calibration. The internal calibration process can take several minutes to complete. Upon completion of the self-calibration process, the ZT412 will respond indicating the status of the calibration. A zero (0) value is returned if the calibration is completed successfully; a one (1) value is returned if the calibration failed; otherwise, a two (2) value is returned to indicate corruption of the calibration. Calibration errors are also reported through the status-reporting



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system. All self-calibration data is stored in non-volatile memory and shall be used as the default, power-on calibration data. If desired, the original factory default calibration data can be restored upon command.

## Identification and Version

Use the *ID Query* to return the ZT412 instrument identification including manufacturer, model number, serial number, and firmware version. The results are returned as a block of ASCII string data up to 44 characters in length.

**Example: ZTEC,ZT412VXI-50,S/N 100,Version 1.00**



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# VXI Interface



## Interface Description

The ZT412 is a message-based VXIbus module that supports both VXIbus Instrument and VXIbus 488.2 Instrument protocols. It is compliant with the instrument specifications outlined in the VXI-1 Revision 1.4 and IEEE Standard 488.2-1992 specifications. In accordance with these specifications, the ZT412 supports a number of levels of communication protocols including low-level VXIbus word-serial commands, IEEE 488.2 common commands. This section describes the low-level VXIbus interface of the ZT412.

## VXIbus Interface

The ZT412 is an A16 message-based slave module with A32 register-based memory. The instrument, as an A16 message-based slave, receives commands using the VXIbus word-serial protocol. In order to support the word-serial protocol, the ZT412 provides a set of A16 accessible registers as shown in Table 9. Each of the registers is defined by detailed bit descriptions given in Tables 9–17. The ZT412 also provides A32 register-based memory that is directly address-mapped in the VXIbus 32-bit address space. The A32 address space is used to transfer waveform data to and from the unit. Table 10 shows the ZT412 A32 address map.

| Offset | Function | Type |
|---|---|---|
| $00_{16}$ | ID Register | Read-Only |
| $02_{16}$ | Device Type Register | Read/Write |
| $04_{16}$ | Status/Control Register | Read/Write |
| $06_{16}$ | Offset Register | Read/Write |
| $08_{16}$ | Protocol Register | Read-Only |
| $0A_{16}$ | Response Register | Read-Only |
| $0C_{16}$ | Unused | |
| $0E_{16}$ | Data Low Register | Read/Write |
| $10_{16}$–$3E_{16}$ | Unused | |

**Table 9: VXIbus A16 Address Space**

| Offset | Function | Type | Size |
|---|---|---|---|
| $0000000_{16}$–$3FFFFFE_{16}$ | Waveform Data Memory (SDRAM) | Read/Write | 64M |

**Table 10: VXIbus A32 Address Space**



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## ID Register

The ID Register is a read-only register located at address offset $00_{16}$. Reading the ID Register returns the ZT412 Device Class, Address Space, and Manufacturer's ID. The Device Class for the ZT412 is Message ($10_2$). The Address Space for the ZT412 is A16/A32 ($01_2$). The Manufacturer's ID for the ZT412 is that of ZTEC Instruments Inc.: 3712 ($0E80_{16}$). Writing to the ID Register has no effect on it. Table 11 defines the function of each bit in the read-only ID Register.

| Bit # | Function | Type | Value | Meaning |
|---|---|---|---|---|
| 15–14 | Device Class | Read | $10_2$ | Message-Based |
| 13–12 | Address Space | Read | $01_2$ | A16/A32 Memory |
| 11–0 | Manufacturer's ID | Read | $E80_{16}$ | ZTEC Instruments |

**Table 11: ID Register Bit Descriptions (Read-Only)**

## Device Type Register

The Device Type Register is a read-only register located at address offset $02_{16}$. Reading the Device Type Register returns the ZT412 Required Memory and Model Code. The Required Memory for the ZT412 is 64 Mbytes for A32 address space. The Model Code for the ZT412 is $412_{10}$ ($19C_{16}$). Writing to the Device Type Register has no effect on it. Table 12 defines the function of each bit in the read-only Device Type Register.

| Bit # | Function | Type | Value | Meaning |
|---|---|---|---|---|
| 15–12 | Required Memory | Read | $5_{16}$ | 64 MBytes |
| 11–0 | Model Code | Read | $19C_{16}$ | ZT412VXI |

**Table 12: Device Type Register Bit Descriptions (Read-Only)**



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## Status/Control Register

The Status/Control Register is a read/write register located at address offset $04_{16}$. Writing to the Status/Control Register changes the Control Register. Table 13 defines the function of each bit in the Control Register. Reading the Status/Control Register returns the contents of the Status Register. Table 14 defines the function of each bit in the read-only Status Register.

| Bit # | Name | Function | Type |
|---|---|---|---|
| 15 | A32 Enable | 0: Disable A32 Memory<br>1: Enable A32 Memory | Write |
| 14–2 | Unused | | |
| 1 | SFInh | 0: Enable Sysfail* Driver<br>1: Inhibit Sysfail* Driver | Write |
| 0 | SReset | 0: Enable Unit<br>1: Soft Reset Unit | Write |

**Table 13: Control Register Bit Descriptions (Write-Only)**

| Bit # | Name | Function | Type |
|---|---|---|---|
| 15 | A32 Active | 0: A32 Memory Inactive<br>1: A32 Memory Active | Read |
| 14 | Mod ID* | 0: Mod ID Line Driven<br>1: Mod ID Line Not Driven | Read |
| 13–4 | Unused | | |
| 3 | Ready | 0: Unit In Configure State<br>1: Unit In Normal Operation State | Read |
| 2 | Passed | 0: Unit Failed Self-Test<br>1: Unit Passed Self-Test | Read |
| 1 | SFInh | 0: Sysfail* Driver Enabled<br>1: Sysfail* Driver Inhibited | Read |
| 0 | SReset | 0: Unit Enabled<br>1: Unit Software Reset | Read |

**Table 14: Status Register Bit Descriptions (Read-Only)**



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## Offset Register

The Offset Register is read/write register located at address offset $06_{16}$. Writing or reading the Offset Register changes or returns the contents of the Offset Register. The Offset Register defines the base address for the ZT412 A32 register-based memory. Only the 5 most-significant bits of the Offset Register are used. Bit 15 is the most-significant A32 address select bit, corresponding to A31 of the address selection. Table 15 defines the function of each bit in the Offset Register.

| Bit # | Name | Function | Type |
|---|---|---|---|
| 15–11 | Offset Address | Address Select for A32 space | Read/Write |
| 10–0 | Unused | | |

**Table 15: Offset Register Bit Descriptions (Read/Write)**

## Protocol Register

The Protocol Register is read-only register located at address offset $08_{16}$. Reading the Protocol Register indicates the additional communication protocols that are supported by the ZT412. The ZT412 supports interrupter capability only. Writing to the Protocol Register has no effect on it. Table 16 defines the function of each bit in the Protocol Register.

| Bit # | Name | Function | Type |
|---|---|---|---|
| 15 | CMDR* | 1: ZT412VXI has Servant-Only capability | Read-Only |
| 14 | Signal Register* | 1: ZT412VXI does not have a Signal Register | Read-Only |
| 13 | Master* | 1: ZT412VXI does not have Master capability | Read-Only |
| 12 | Interrupter | 1: ZT412VXI has Interrupter capability | Read-Only |
| 11 | FHS* | 1: ZT412VXI does not support Fast Handshake | Read-Only |
| 10 | Shared Memory* | 1: ZT412VXI does not support Shared Memory | Read-Only |
| 9–0 | unused | 1: Unused | Read-Only |

**Table 16: Protocol Register Bit Descriptions (Read-Only)**



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## Response Register

The Response Register is read-only register located at address offset $0A_{16}$. A read of the Response Register returns the status of the communication registers on the ZT412. Writing to the Response Register has no effect on it. Table 17 defines the read-only functions for each bit in the Response Register.

| Bit # | Name | Function | Type |
|---|---|---|---|
| 15 | Unused | 0: Unused | Read-Only |
| 14 | Unused | 1: Unused | Read-Only |
| 13 | DOR | 1: Data Out ready for Byte Request | Read-Only |
| 12 | DIR | 1: Data In ready for Byte Available | Read-Only |
| 11 | ERR* | 0: Error in Word Serial Protocol | Read-Only |
| 10 | Read Ready | 1: Ready for VXI Read Operation | Read-Only |
| 9 | Write Ready | 1: Ready for VXI Write Operation | Read-Only |
| 8–0 | Unused | 1: Unused | Read-Only |

**Table 17: Response Register Bit Descriptions (Read-Only)**

## Data Low Register

The Data Low Register is read/write register located at address offset $0E_{16}$. Writing or reading the Data Low Register provides the mechanism to transmit word-serial commands between the VXIbus host processor and the ZT412. Writing to the Data Low register causes the ZT412 to perform some action. Responses to these actions can be read back from the Data Low Register.

| Bit # | Name | Function | Type |
|---|---|---|---|
| 15–0 | Data Low | Word Serial Message To/From ZT412VXI | Read-Write |

**Table 18: Data Low Register Bit Descriptions (Read-Write)**



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## A32 Address Space

The ZT412 contains up to 64 Mbytes (32 MSamples) of register-based memory in the VXIbus A32 address space. This memory is used to store and transfer blocks of waveform data to the VXIbus host processor. In order to maximize data transfer rates, the waveform data is available through direct register-based data transfers. Each waveform data sample requires two bytes to store the 16-bit data. The SDRAM memory is available as VXIbus A32 address space.

Writing to the ZT412



**Step-by-Step**

To write reference waveforms to the ZT412:

1. Load data into the A32 space.
2. Issue TRAC:LOAD:REF command.
3. Issue *OPC? Query, and then wait for a “1” to be returned indicating the load is complete.

Reading from the ZT412



**Step-by-Step**

To read input, calculate or reference waveforms from the ZT412:

1. Issue TRAC:LOAD:INP?, TRAC:LOAD:CALC? or TRAC:LOAD:REF? query.
2. Wait for a “1” to be returned indicating operation complete.
3. Read data from A32 space.

# Low-Level VXIbus Commands

The ZT412 is a message-based VXIbus instrument supporting low-level VXIbus commands. These commands are sent to the ZT412 by *reads of* and *writes to* its Data Low Register using the VXIbus word-serial protocol. Each command is defined with a unique 16-bit value that is written to the Data Low Register. These low-level commands are used by the VXIbus processor at its lowest level of data transfer protocol (transparent to most users). Most users need not concern themselves with these commands, which are listed in Table 19. More information on the low-level VXIbus commands and the word-serial protocol can be found in the VXIbus specification.



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| Command | Function |
|---|---|
| Byte Available | Sends a byte of data to the ZT412. |
| Byte Request | Requests a byte of data from the ZT412. |
| Abort Normal Operation | Causes ZT412 to cease all operations immediately and enter its configuration state. |
| Begin Normal Operation | Notifies ZT412 that it can begin normal operations and enter its normal-operation state. |
| End Normal Operation | Causes ZT412 to cease all operations in an orderly fashion and enter its configuration state. |
| Clear | Clears the VXIbus interface and any pending operations on the ZT412. |
| Asynchronous Mode Control | Directs the path of events and responses on the ZT412. |
| Control Event | Selectively enables the generation of events by the ZT412. |
| Read STB | Requests the reporting of the Status Byte from the ZT412. |
| Read Protocol | Requests the reporting of protocols supported by the ZT412 (EG, I, I4). |
| Read Protocol Error | Requests the reporting of the current error state of the ZT412 and resets all asserted errors. |
| Assign Interrupter Line | Assigns a particular backplane IRQn* line to the ZT412 for asserting interrupts. |
| Read Interrupter Line | Requests the reporting of the current IRQn* line assigned to the ZT412. |
| Read Interrupters | Requests the reporting of the number of interrupters within the ZT412 (One) |

**Table 19: Low-Level VXIbus Commands**



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# Command Reference



This chapter describes IEEE 488.2 Common (*) commands and Standard Commands for Programmable Instruments (SCPI) applicable to the ZT412.

## Common Command Format

The IEEE 488.2 standard defines the Common Commands that perform functions like reset, self-test, status byte query, etc. Common commands are four or five characters in length, always begin with the asterisk character (*), and may include one or more parameters. The command keyword is separated from the first parameter by a space character. Some examples of Common Commands are shown below:

- *RST
- *CLS
- *STB?

## SCPI Command Format

Standard Commands for Programmable Instruments (SCPI) perform functions like setting parameters, performing measurements, querying instrument states, and retrieving data. A subsystem command structure is a hierarchical structure that usually consists of a top level (or root) command, one or more lower-level subcommands, and their parameters. The following example shows part of a typical subsystem:

```
[SENSe:]
    INPut<number>
        :COUPling AC | DC
            :IMPedance?
```

[SENSe:] is the root command, :INPut is the second-level subcommand with <number> as a parameter, and :COUPling and :IMPedance? are third-level commands/queries with AC | DC as a parameter.



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## Command Separator

A colon (:) always separates one command from the next lower level command as shown below:

**[SENSe:]INPut<n>:IMPedance?**

Colons separate the root command from the second-level command ([SENSe:]INPut), and the second-level from the third-level query (INPut<n>:IMPedance?).

## Abbreviated Commands

The command syntax shows most commands as a mix of upper and lower case letters. The upper case letters indicate the abbreviated spelling for the command. For shorter program lines, send only the abbreviated form. For better program readability, you may send the entire command. The instrument will only accept either the abbreviated form or the entire command.

For example, if the command syntax shows *IMPedance?*, then *IMP?* and *IMPedance?* are both acceptable forms. Other forms of *IMPedance?*, such as *IM?*, will generate an error. You may use upper or lower case letters. Therefore, *IMPEDANCE?* and *IMPeDaNcE?* are acceptable.

## Implied Commands

Implied commands are those which appear in square brackets ([ ]) in the command syntax. (Note that the brackets are not part of the command and are not sent to the instrument.) If a root level and second-level command are sent, but not a third-level implied command, the instrument assumes use of an implied command. Examine the portion of the [SENSe:] subsystem shown below:

**[SENSe:]**
**INPut<n>**
**:COUPling AC | DC**
**:IMPedance?**

The first-level command [SENSe:] is an implied command. To query the instrument's input 1 impedance selection, send either of the following command statements:

**[SENS:]INP1:IMP?** *or* **INP1:IMP?**



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## Parameters

The following table contains explanations and examples of parameter types.

| Parameter Type | Explanations and Examples |
|---|---|
| Mask | Bit mask (<mask>) where every bit represents a condition or event. |
| Numeric | Accepts all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation.<br><br>123 or 1.23E2; -123 or -1.23E2; .123, 1.23E-1, or 1.23000E-01.<br><br>Accepts all commonly used suffixes with decimal representations of numbers, including optional sgns and decimal points.<br><br>.123S or 123MS; 1234OHM or 1.234KOHM.<br><br>Voltage = "UV" for E-6, "MV" for E-3, "V"for E0, "KV" for E3<br>Percent = "PCT"<br>Ohms = "OHM", "KOHM" for E3, "MOHM" for E6.<br>Frequency = "HZ" for E0, "KHZ" for E3, "MHZ" for E6, "GHZ" for E9.<br>Time = "PS" for E-12, "NS" for E-9, "US" for E-6, "MS" for E-3, "S" for E0.<br>Phase = “DEG” for (π/180) degrees or “RAD” for radians<br><br>Special cases include MIN and MAX. MIN (selects minimum value available), and MAX (selects maximum value available).<br><br>Numeric values are:<br><br>1. Integer Numbers<br>• Unsigned 16-bit (U16)—range of 0 to 65535<br>• Signed 16-bit (S16)—range of -32768 to 32767<br>• Unsigned 32-bit (U32)—range of 0 to 4,294,967,295<br>• Signed 32-bit (S32)—range of -2,147,483,648 to 2,147,483,647<br><br>2. Standard 32-bit Floating Point (Float)<br><br>**Note:** All command parameters represented as floating point numbers sent to the ZT412VXI must have 12 digits or less, including before and after the decimal point. Examples: 123456.789012 or 0.12345678901 |
| Discrete | Selects from a finite number of values. These parameters use mnemonics to represent each valid setting.<br><br>An example is the [SENSe:]INPut<n> COUPling <mode> command, where <mode> can be AC or DC.<br><br>Another example is a single binary condition that is either true or false.<br><br>1 or ON; 0 or OFF |

**Table 20: Parameter Types**



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Optional Parameters

Parameters shown within square brackets ([ ]) are optional parameters. (Note that the brackets are not part of the command and are not sent to the instrument.) If you do not specify a value for an optional parameter, the instrument chooses a default value.

Parameters Out of Range

An out of range parameter is automatically adjusted to the closest acceptable value. For example, if INP1:ATT 0.1 is entered, the value is set to 0.9 (lowest available setting).

# Linking Commands

## Linking IEEE 488.2 Common Commands with SCPI Commands

Use a semicolon between the commands.

For example: ***CLS;*RST;AUT**

## Linking Multiple SCPI Commands

Use both a semicolon and a colon between the commands.

For example: **INP1:COUP AC;:SYST:ERR?**

SCPI also allows several commands within the same subsystem to be linked with a semicolon.
For example: **INP1:COUP AC;:INP1:RANG 10** *or* **INP1:COUP AC;RANG 10**



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# IEEE 488.2 Common Commands

The following is an alphabetic list of IEEE 488.2 Common Commands.

<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calibrate Query<br>*CAL?</td><td>Initiates and returns the results of the unit self-calibration process. The internal calibration determines the zero DC offset, the DC offset adjust scale factor, and the ADC balance for all input range settings for all input channels. The internal calibration process can take several minutes to complete. The instrument is reset upon completion of the calibration process.<br><br>Note: The input channels must be disconnected or be driven with 0.0 VDC before starting the calibration.<br><br>The timeout value should be set to infinite before starting the calibration, and reset to the default value when completed.<br><br>Note: Do not interrupt the instrument during calibration or the calibration tables could be corrupted.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>*CAL? → <result><br><br>Parameters:<br><table><tr><th>Name</th><th>Type</th><th>Range</th></tr><tr><td><result></td><td>U16</td><td>0 Pass<br>1 Fail (Did not converge)<br>2 Corrupt</td></tr></table></td></tr>
<tr><td>Clear Status Command<br>*CLS</td><td>The clear status command clears all event registers, the request for OPC flag, and all status queues (except the response queue).<br><br>Command Syntax<br>*CLS<br><br>Query Syntax<br>None<br><br>Parameters:<br>None</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Event Status Enable Command<br>*ESE<br><br>Event Status Enable Query<br>*ESE?</td><td>Sets and returns the state of the event status enable register. The event status enable register allows the enabled standard events to affect the event summary status bit within the status byte.<br><br>Command Syntax<br>*ESE <enable><br><br>Query Syntax<br>*ESE? → <enable><br><br>Parameters<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><enable></td><td>U16</td><td>0 to 255<br>Bit 0: Operation Complete<br>Bit 1: Request Control<br>Bit 2: Query Error<br>Bit 3: Device Dependent Error<br>Bit 4: Execution Error<br>Bit 5: Command Error<br>Bit 6: User Request<br>Bit 7: Power on</td></tr></table></td></tr>
<tr><td>Event Status Register Query<br>*ESR?</td><td>The event status register query returns the state of the event status register. The event status register provides the standard event status information.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>*ESR? → <state><br><br>Parameters<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><state></td><td>U16</td><td>0 to 255<br>Bit 0: Operation Complete<br>Bit 1: Request Control<br>Bit 2: Query Error<br>Bit 3: Device Dependent Error<br>Bit 4: Execution Error<br>Bit 5: Command Error<br>Bit 6: User Request<br>Bit 7: Power on</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Identification Query<br>*IDN?</td><td>The identification query returns the instrument identification information. The response contains four fields separated by commas in the form:<br><br>“Manufacturer, model number, serial number, firmware revision level.”<br><br>Command Syntax<br>None<br><br>Response Syntax<br>*IDN? → <id_string><br><br>Parameters<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><id_string></td><td>String</td><td>See above</td></tr></table></td></tr>
<tr><td>Operation Complete Command<br>*OPC<br><br>Operation Complete Query<br>*OPC?</td><td>The command sets the request for the operation complete flag when all pending operations have completed. When all operations have completed, the operation complete bit in the event status register will be set.<br><br>The query returns a 0 to indicate that all pending operations have <u>not</u> completed and a 1 to indicate that all pending operations have completed.<br><br>Command Syntax<br>*OPC<br><br>Query Syntax<br>*OPC? → <state><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><state></td><td>U16</td><td>0 All operations are not complete<br>1 All operations complete</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Recall Instrument State Command<br>*RCL</td><td>Recalls the selected saved instrument state from non-volatile memory.<br><br>Command Syntax<br>*RCL <number><br><br>Query Syntax<br>None<br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><number></td><td>U16</td><td>1 to 31</td></tr></table></td></tr>
<tr><td>Reset Command<br>*RST</td><td>Performs a hardware reset function that returns the instrument to the initial default condition. Status registers are <u>not</u> cleared.<br><br>Command Syntax<br>*RST<br><br>Query Syntax<br>None<br><br>Parameters:<br>None</td></tr>
<tr><td>Save Instrument State Command<br>*SAV</td><td>Stores the current state of the instrument to the selected storage index in non-volatile memory.<br><br>Command Syntax<br>*SAV <number><br><br>Query Syntax<br>None<br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><number></td><td>U16</td><td>1 to 31</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Service Request Enable Command<br>*SRE<br><br>Service Request Enable Query<br>*SRE?</td><td>Selects and returns the enabled bits for the Status Byte. The parameter is a bit mask which enables the corresponding status byte bits.<br><br>Command Syntax<br>*SRE <enable><br><br>Query Syntax<br>*SRE? → <enable><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><enable></td><td>U16</td><td>0 to 65535<br>Bit 0: Unused<br>Bit 1: Unused<br>Bit 2: Error Log Not Empty<br>Bit 3: Questionable Summary<br>Bit 4: Message Available<br>Bit 5: Standard Event Summary<br>Bit 6: Master Summary Status<br>Bit 7: Operation Summary</td></tr></table></td></tr>
<tr><td>Status Byte Query<br>*STB?</td><td>Returns the Status Byte.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>*STB? → <mask><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><mask></td><td>U16</td><td>0 to 65535<br>Bit 0: Unused<br>Bit 1: Unused<br>Bit 2: Error Log Not Empty<br>Bit 3: Questionable Summary<br>Bit 4: Message Available<br>Bit 5: Standard Event Summary<br>Bit 6: Master Summary Status<br>Bit 7: Operation Summary</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger Immediate Command<br>*TRG</td><td>Causes an immediate trigger event for any selected trigger source. If enabled, the trigger outputs on the VXIbus backplane will also toggle when a trigger immediate command is issued.<br><br>Command Syntax<br>*TRG<br><br>Query Syntax<br>None<br><br>Parameters:<br>None</td></tr>
<tr><td>Test Query<br>*TST?</td><td>Initiates an instrument self test and returns the test results as a 16-bit code. The self test is initiated on instrument power up.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>*TST? → <code><br><br>Parameters:<br><table><tr><th>Name</th><th>Type</th><th>Range</th></tr><tr><td><code></td><td>U16</td><td>0 to 65535<br>Bit 0: Baseboard Test Failed<br>Bit 1: SRAM Test Failed<br>Bit 2: ROM Test Failed<br>Bit 3: Unused<br>Bit 4: Ref Oscillator Test Failed<br>Bit 5: DRAM Test Failed<br>Bit 6: Flash Memory Test Failed<br>Bit 7: Unused<br>Bit 8: Input 1–2 Register Test Failed<br>Bit 9: Input1 RAM Test Failed<br>Bit 10: Input2 RAM Test Failed<br>Bit 11: PLL Test Failed<br>Bit 12: Input 3–4 Register Test Failed<br>Bit 13: Input3 RAM Test Failed<br>Bit 14: Input4 RAM Test Failed<br>Bit 15: Unused</td></tr></table></td></tr>
</table>



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| Name | Description |
| --- | --- |
| **Wait to Continue Command**<br>*WAI | Allows the user to force the interface to wait until operations are complete before resuming.<br><br>**Command Syntax**<br>*WAI<br><br>**Query Syntax**<br>None<br><br>**Parameters:**<br>None |



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# SCPI Commands and Queries

The SCPI Commands are presented in an alphabetic list below. Each SCPI command parameter table includes parameter name, parameter type, and range of values. The parameter type follows the definition and information given in Table 20.

<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Abort Command</td><td>Terminates waveform capture. When an abort is received the unit will end any on-going capture activity and return to its idle state. The waveform being captured will be dropped but any previous captured waveforms will be available. The unit start state can be queried from the Status Register.<br><br>Command Syntax<br>ABORt<br><br>Query Syntax<br>None<br><br>Parameters<br>None</td></tr>
<tr><td>Arm Command<br><br>Arm Query</td><td>Arms or disarms the unit through software when manual arm source selected. The unit will begin trigger detection when armed. When disarmed, the unit ignores triggers. The Arm Query returns the arm condition.<br><br>Command Syntax<br>ARM[IMMediate] <state><br><br>Query Syntax<br>ARM? → <state><br><br>Parameters<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><state></td><td>Discrete</td><td>ON or 1 (Arm)<br>OFF or 0 (Disarm)</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Arm Polarity Command<br><br>Arm Polarity Query</td><td>
Description<br>
Sets or queries the active state of the selected source. If an arm source is selected and the state of the selected source matches the ARM POLARITY state, the unit will arm. The following considerations apply when setting the arm polarity:<br><br>
• POSitive state defines the active state as the selected source in its high state<br><br>
• NEGative state defines the active state as the selected source in its low state<br><br>
Command Syntax<br>
ARM:POLarity <polarity><br><br>
Query Syntax<br>
ARM:POLarity? → <polarity><br><br>
Parameters<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><polarity></td><td>Discrete</td><td>NEGative (negative polarity)<br>POSitive (positive polarity)</td></tr>
</table>
</td></tr>
</table>

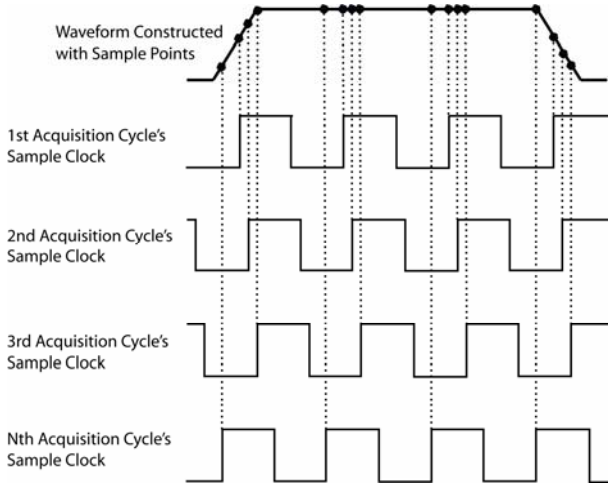


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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Arm Source Command<br><br>Arm Source Query</td><td>Sets or queries the Arm Source setting that will be used to arm the unit. For example, if the Arm Source Command is set to ARM, the front panel ARM IN signal will be used to arm the unit. If an immediate output is desired regardless of trigger, Arm Source Command can be set to IMMediate.<br><br>Command Syntax<br>ARM:SOURce <source><br><br>Query Syntax<br>ARM:SOURce?<br><br>Parameters<br><table><tr><th>Name</th><th>Type</th><th>Range</th></tr><tr><td><source></td><td>Discrete</td><td>ARM — Front panel ARM IN signal<br>TTLTrg<n> — VXIbus TTL trigger line, where <n> may be 0, 1, 2, 3, 4, 5, 6, or 7<br>ECLTrg<n> — VXIbus ECL trigger line, where <n> may be 0 or 1<br>MANual — Manual arm<br>IMMediate — Bypass arm detection<br>EXTernal<n> — Front panel TRG IN signal</td></tr></table></td></tr>
<tr><td>Auto Scale Command</td><td>Commands the instrument to auto scale on enabled channels only. Auto scale changes the range, offset, impedance, sample rate, trigger source, and trigger level based on the input signal. It also sets the number of points to 1000.<br><br>Command Syntax<br>[SENSe]:AUToscale<br><br>Query Syntax<br>None<br><br>Parameters<br>None</td></tr>
</table>



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| Name | Description |
|---|---|
| **Average Count Command**<br><br>**Average Count Query** | Sets or queries the acquisition count for repetitive acquisition modes:<br><br>• In Scalar (Average) mode, this specifies the number of waveforms to be averaged before the acquisition is complete.<br><br>• In Envelope mode, this specifies the number of waveforms for which to capture minimum and maximum values before the acquisition is complete.<br><br>• In Equivalent Time mode, a picture of a repetitive waveform is constructed by capturing a little bit of information from each repetition. Because the points appear randomly along the waveform, it is important to note that an entire waveform may <u>not</u> be constructed unless there are sufficient repetitions. Unfilled points will be constructed using a zero-order hold and are flagged with a "1" in the LSB of the 16-bit waveform code. Also, the number of points per point can be set to increase the resolution of the waveform. (See the *Average Equivalent Time Points Command*).<br><br><br><br><br>**Command Syntax**<br>[SENSe]:AVERage:COUNt <count><br><br>**Query Syntax**<br>[SENSe]:AVERage:COUNt? → <count><br><br>**Parameters:**<br><br>Name \| Type \| Range<br><count> \| U16 \| 2 to 65535<br>MINimum (2)<br>MAXimum (65535) |



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Average Envelope View Command<br><br>Average Envelope View Query</td><td>Sets or queries the active envelope view, that is, controls which envelope view to set active. The default view is MINimum.<br><br>Command Syntax<br>[SENSe]:AVERage:ENVelope:VIEW <view><br><br>Query Syntax<br>[SENSe]:AVERage:ENVelope:VIEW? → <view><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><view></td><td>Discrete</td><td>MINimum<br>MAXimum</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Average Equivalent Time Points Command<br><br>Average Equivalent Time Points Query</td><td>Sets or queries the number of user-defined points-per-point for equivalent time sampling of a waveform. When a DSO uses equivalent time sampling, it can acquire any signal up to the analog bandwidth of the scope regardless of the sample rate. In this mode, the scope gathers the necessary number of samples across several triggers. The following considerations apply when using the Average Equivalent Time Points Command and Average Equivalent Time Points Query:<br><br>• The waveform is constantly sampled and digitized.<br><br>• The sampling rate is determined by the instrument clock and not the trigger repetition rate.<br><br>• The input signal must be repetitive to generate the multiple triggers needed for equivalent-time sampling<br><br>• The points-per-point value is user-defined at 2 to 100 points per waveform point.<br><br>• Since each calculation channel is limited to a maximum waveform size of 32K, the waveform size must be less than 32k / points-per-point value.<br><br>• Very precise time interval measurements can be made on very high bandwidth waveforms.<br><br>• The trigger source must be set to an enabled input channel.<br><br>Command Syntax<br>[SENSe]:AVERage:ETIMe:POINts <points><br><br>Query Syntax<br>[SENSe]:AVERage:ETIMe:POINts? → <points><br><br>Parameters:<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><points></td><td>U16</td><td>2 to 100<br>MINimum (2)<br>MAXimum (100)</td></tr></table></td></tr>
</table>

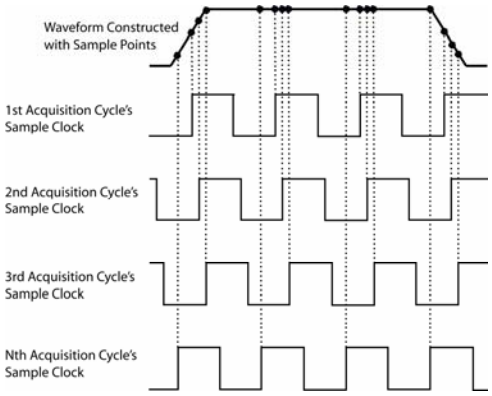


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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Average State Command<br><br>Average State Query</td><td>Sets or queries the waveform averaging state. The following considerations apply when using the Average State Command and Average State Query:<br><br>• When averaging is enabled, only the final output waveform is retained; the raw, un-averaged data is not available.<br><br>• When averaging is disabled, (Normal acquisition mode), waveforms from the digitizers are passed through without modification.<br><br>• The number of waveforms averaged and the average operation mode can be selected using the Average Count Command and Average Type Command respectively.<br><br>• The average enable setting affects all active input channels.<br><br>Command Syntax<br>[SENSe]:AVERage[:STATe] <state><br><br>Query Syntax<br>[SENSe]:AVERage[:STATe]? → <state><br><br>Parameters:<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><state></td><td>Discrete</td><td>ON or 1 Enable Averaging<br>OFF or 0 Disable Averaging</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Average Type Command<br><br>Average Type Query</td><td>Sets or queries the type of acquisition that is to take place.<br><br>• In Scalar mode, multiple captured waveforms are averaged together, providing higher resolution and less noise. In Scalar mode, only one channel per channels 1-2 and one channel per channels 3-4 may be enabled.<br><br>• In Envelope mode, the minimum and maximum waveform points from multiple acquisitions are combined to form a waveform (an envelope) that shows min/max changes over time. In Envelope mode, only one channel per channels 1-2 and one channel per channels 3-4 may be enabled<br><br>• In Equivalent Time mode, a picture of a repetitive waveform is constructed by capturing a little bit of information from each repetition. Because the points appear randomly along the waveform, it is important to note that an entire waveform may <u>not</u> be constructed unless there are sufficient repetitions. Unfilled points will be constructed using a zero-order hold and are flagged with a “1” in the LSB of the 16-bit waveform code. Also, the number of points per point can be set using the Average Equivalent Time Points Command to increase the resolution of the waveform.<br><br>

<br><br>Command Syntax<br>[SENSe]:AVERage:TYPE <type><br><br>Query Syntax<br>[SENSe]:AVERage:TYPE? → <type><br><br>Parameters:
<table>
<tr><th>Name</th><th>Type</th><th colspan="2">Range</th></tr>
<tr><td><type></td><td>Discrete</td><td>SCALar<br>ENVelope<br>ETIMe</td><td>Average<br>Envelope<br>Equivalent Time</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Absolute Value Command</td><td>Sets Calculate Channel to determine the absolute value of a waveform and place the result in its output, point by point.<br><br>Command Syntax<br>CALCulate<n>:AVALue <source><br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Add Command</td><td>Sets Calculate Channel to add two waveforms (source1 and source2) and place the result in its output.<br><br>Command Syntax<br>CALCulate<n>:ADD <source1>,<source2><br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><source1></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><source2></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Copy Command</td><td>Sets Calculate Channel to copy a source waveform into its output.<br><br>Command Syntax<br>CALCulate<n>:COPY <source><br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Data Format Command<br><br>Calculate Data Format Query</td><td>Sets or queries the data format for FFT waveforms (frequency transform calculate data). The default data format is linear, and causes waveforms to be represented in linear codes that can be converted to Volts using the calculate channel preamble. Logarithmic data format causes post-processing of the linear magnitude data into logarithmic codes. Log data codes can be converted to dBV using the calculate channel preamble. The following considerations apply:<br><br>• Log data applies to FFT waveforms only.<br><br>• When converting to log, zeros and negatives are increased to the lowest positive voltage code (-32767)<br><br>Command Syntax<br>CALCulate<n>:FORMat <format><br><br>Query Syntax<br>CALCulate<n>:FORMat? → <format><br><br>Parameters:
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><format></td><td>Discrete</td><td>LINear<br>LOGarithmic</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Derivative Command</td><td>Sets Calculate Channel <n> to calculate the derivative of a source waveform and place the result into its output.<br><br>Command Syntax<br>CALCulate<n>:DERivative <source><br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Function Query</td><td>Queries the current Calculate Channel function. Although two sources are always returned, the second source may be ignored for functions that only require one source.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>CALCulate<n>:FUNCtion? → <function>, <source1>,<source2><br><br>Parameters:
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><function></td><td>Discrete</td><td>ADD Add<br>AVALue Absolute Value<br>COPY Copy<br>DERivative Derivative<br>INTegral Integral<br>INVert Invert<br>MULTiply Multiply<br>SUBTract Subtract<br>LIMit Limit<br>FTRanform Frequency Transform<br>TTRransform Time Transform</td></tr>
<tr><td><source1></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><source2></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Immediate Command</td><td>Forces the instrument to immediately perform calculations on the calculation channel.<br><br>Command Syntax<br>CALCulate<n>:IMMediate<br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
</table>
</td></tr>
<tr><td>Calculate Integral Command</td><td>Sets Calculate Channel to calculate the integral of a source waveform and place the result into its output.<br><br>Command Syntax<br>CALCulate<n>:INTegral <source><br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Invert Command</td><td>Sets Calculate Channel <n> to invert the sign of a source waveform and place the result into its output.<br><br>Command Syntax<br>CALCulate<n>:INVert <source><br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
</table>
</td></tr>
<tr><td>Calculate Limit Test Clear Command</td><td>Clears the statistics from a limit or mask test for the specified calculation channel.<br><br>Command Syntax<br>CALCulate<n>:LIMit:CLEar<br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Limit Test Command</td><td>Configures the instrument to perform a limit test.<br><br>Command Syntax<br>CALCulate<n>:LIMit <source><br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
</table>
</td></tr>
<tr><td>Calculate Limit Test Continuous Command<br><br>Calculate Limit Test Continuous Query</td><td>Sets or returns if the calculation channel is doing a continuous limit test. Continuous ON runs the limit test until aborted. Continuous OFF stops the limit test upon the first failure.<br><br>Command Syntax<br>CALCulate<n>:LIMit:CONTinuous <state><br><br>Query Syntax<br>CALCulate<n>:LIMit:CONTinuous? → <state><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><state></td><td>Discrete</td><td>ON or 1 Limit Test Continuous ON<br>OFF or 0 Limit Test Continuous OFF</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Limit Test Fail Query</td><td>Returns whether the limit test has failed. A “0” indicates no failures and a “1” indicates a failed limit test.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>CALCulate<n>:LIMit:FAIL? → <fail_num><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr><tr><td><fail_num></td><td>Discrete</td><td>0 No Failures<br>1 Failed Limit Test</td></tr></table></td></tr>
<tr><td>Calculate Limit Test Lower Command<br><br>Calculate Limit Test Lower Query</td><td>Sets or returns the lower limit for a limit test.<br><br>Command Syntax<br>CALCulate<n>:LIMit:LOWer <value><br><br>Query Syntax<br>CALCulate<n>:LIMit:LOWer? → <value><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr><tr><td><value></td><td>Float</td><td>Variable</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Limit Test Measurement Command<br><br>Calculate Limit Test Measurement Query</td><td>Set or queries the measurement to use for the limit test.<br><br>Command Syntax<br>CALCulate<n>:LIMit:MEASure <meas><br><br>Query Syntax<br>CALCulate<n>:LIMit:MEASure? → <meas><br><br>Parameters:
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><meas></td><td>Discrete</td><td>AC AC RMS<br>AMPLitude Amplitude<br>AVERage Average<br>CAVerage Cycle Average<br>CFRequency Cycle Frequency<br>CPERiod Cycle Period<br>CRMS Cycle RMS<br>DC DC RMS<br>ENOB Effective Number of Bits<br>FOVershoot Fall Overshoot<br>FPReshoot Fall Preshoot<br>FTCRoss Fall Crossing Time<br>FTIMe Fall Time<br>FREQuency Frequency<br>HIGH High<br>LOW Low<br>MAXimum Maximum<br>MINimum Minimum<br>MID Middle<br>NDUTycycle Negative Duty<br>NWIDth Negative Width<br>PAC Precision AC RMS<br>PDC Precision DC RMS<br>PDUTycycle Positive Duty<br>PWIDth Positive Width<br>PERiod Period<br>PHASe Phase<br>PTPeak Peak-to-peak<br>ROVershoot Rise Overshoot<br>RPReshoot Rise Preshoot<br>RTCRoss Rise Crossing Time<br>RTIMe Rise Time<br>SFDR Spurious-Free Dynamic Range<br>SNDR S/N & Distortion Ratio<br>SNR Signal-to-Noise Ratio<br>THD Total Harmonic Distortion<br>TMAXimum Time of Maximum<br>TMINimum Time of Minimum<br>MASK Mask</td></tr>
</table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Limit Test Report Query</td><td>Returns all of the limit test reports for a calculation channel. The values returned include the number of tests performed, the number of test failures encountered, the minimum measurement result, the maximum measurement result, the average measurement result, and the most recent measurement performed.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>CALCulate<n>:LIMit:REPort? → <count>,<fail_num>,<min>,<max><br><average>,<last_val><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><count></td><td>U16</td><td>0 to 65535</td></tr>
<tr><td><fail_num></td><td>U16</td><td>0 to 65535</td></tr>
<tr><td><min></td><td>Float</td><td>Variable</td></tr>
<tr><td><max></td><td>Float</td><td>Variable</td></tr>
<tr><td><average></td><td>Float</td><td>Variable</td></tr>
<tr><td><last_val></td><td>Float</td><td>Variable</td></tr>
</table>
</td></tr>
<tr><td>Calculate Limit Test Upper Command<br><br>Calculate Limit Test Upper Query</td><td>Sets or returns the upper limit for a limit test.<br><br>Command Syntax<br>CALCulate<n>:LIMit:UPPer <value><br><br>Query Syntax<br>CALCulate<n>:LIMit:UPPer? → <value><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><value></td><td>Float</td><td>Variable</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Mask Test Lower Command<br><br>Calculate Mask Test Lower Query</td><td>Sets or returns the source to use for the lower reference for a mask test.<br><br>Note: Do not perform a mask test where the calculation source and destination use the same calculation channel.<br><br>Command Syntax<br>CALCulate<n>:LIMit:MASK:LOWer <source><br><br>Query Syntax<br>CALCulate<n>:LIMit:MASK:LOWer?<br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>CALC1 Calculation Channel 1<br>CALC2 Calculation Channel 2</td></tr>
<tr><td><source></td><td>Discrete</td><td>REFerence<n><br>REF1 Reference Channel 1<br>REF2 Reference Channel 2<br>REF3 Reference Channel 3<br>REF4 Reference Channel 4<br><br>Note: Reference channels are only mask sources for Mask tests.</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Mask Test Upper Command<br><br>Calculate Mask Test Upper Query</td><td>Sets or returns the source to use for the upper reference for a mask test.<br><br>Note: Do not perform a mask test where the calculation source and destination use the same calculation channel.<br><br>Command Syntax<br>CALCulate<n>:LIMit:MASK:UPPer <source><br><br>Query Syntax<br>CALCulate<n>:LIMit:MASK:UPPer?<br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>CALC1 Calculation Channel 1<br>CALC2 Calculation Channel 2</td></tr>
<tr><td><source></td><td>Discrete</td><td>REFerence<n><br>REF1 Reference Channel 1<br>REF2 Reference Channel 2<br>REF3 Reference Channel 3<br>REF4 Reference Channel 4<br><br>Note: Reference channels are only mask sources for Mask tests.</td></tr>
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</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Multiply Command</td><td>Sets the Calculation Channel to multiply two waveforms and place the result in its output.<br><br>Command Syntax<br>CALCulate<n>:MULTiply <source1>,<source2><br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><source1></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><source2></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
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</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate State Command<br><br>Calculate State Query</td><td>Sets or queries the Calculate Channel processing enable. Enabled channels are processed upon every capture cycle. Disabled channels may be processed after a waveform capture using the Calculate Immediate Command.<br><br>When a Calculate Channel is initially configured, the unit selects a nominal voltage range and offset for the selected calculate operation. This nominal voltage range and offset may not be optimum for the applied signals and can be modified using the Calculate Voltage Range Command and the Calculate Voltage Offset Command.<br><br>Command Syntax<br>CALCulate<n>[:STATe] <state><br><br>Query Syntax<br>CALCulate<n>[:STATe]? → <state><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><state></td><td>Discrete</td><td>ON or 1 Active<br>OFF or 0 Inactive</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Subtract Command</td><td>Sets the Calculation Channel to subtract two waveforms and place the result in its output. The result is generated by source1 – source2.<br><br>Command Syntax<br>CALCulate<n>:SUBTract <source1>,<source2><br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><source1></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><source2></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Transform Frequency Command</td><td>Sets the instrument to calculate an FFT.<br><br>Command Syntax<br>CALCulate<n>:TRANsform:FREQuency <source><br><br>Query Syntax<br>None<br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr></table></td></tr>
<tr><td>Calculate Transform Frequency Window Command<br><br>Calculate Transform Frequency Window Query</td><td>Sets or queries the type of Transform Frequency window to use when calculating an FFT.<br><br>Command Syntax<br>CALCulate<n>:TRANsform:FREQuency:WINDow <window><br><br>Query Syntax<br>CALCulate<n>:TRANsform:FREQuency:WINDow? → <window><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr><tr><td><window></td><td>Discrete</td><td>RECTangular Rectangular<br>HAMMing Hamming<br>HANNing Hanning<br>BLACkman Blackman</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Transform Time Command</td><td>Sets the instrument to perform a time transform on a waveform. A time transform performs a second order IIR low pass filter operation on the data.<br><br>Command Syntax<br>CALCulate<n>:TRANsform:TIME <source><br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
</table>
</td></tr>
<tr><td>Calculate Transform Time Points Command<br><br>Calculate Transform Time Points Query</td><td>Sets or queries the number of filter length points used to calculate a Time Transform.<br><br>Command Syntax<br>CALCulate<n>:TRANsform:TIME:POINts <points><br><br>Query Syntax<br>CALCulate<n>:TRANsform:TIME:POINts? → <points><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr>
<tr><td><points></td><td>U16</td><td>2 to 40 points<br>MINimum 2<br>MAXimum 40</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calculate Voltage Offset Command<br><br>Calculate Voltage Offset Query</td><td>Sets or queries the DC voltage offset for the Calculate Channel that is represented at the vertical center for the selected channel.<br><br>When a Calculate Channel is initially configured, the unit selects a nominal voltage range and offset for the selected calculate operation. This nominal voltage range and offset may not be optimum for the applied signals and can be modified using the Calculate Voltage Range Command and the Calculate Voltage Offset Command.<br><br>Command Syntax<br>CALCulate<n>:OFFSet <volts><br><br>Query Syntax<br>CALCulate<n>:OFFSet? → <volts><br><br>Parameters:<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr><tr><td><volts></td><td>Float</td><td>Variable</td></tr></table></td></tr>
<tr><td>Calculate Voltage Range Command<br><br>Calculate Voltage Range Query</td><td>Sets or queries the expected range for the Calculate Channel.<br><br>When a Calculate Channel is initially configured, the unit selects a nominal voltage range and offset for the selected calculate operation. This nominal voltage range and offset may not be optimum for the applied signals and can be modified using the Calculate Voltage Range Command and the Calculate Voltage Offset Command.<br><br>Command Syntax<br>CALCulate<n>:RANGe <range><br><br>Query Syntax<br>CALCulate<n>:RANGe? → <volts><br><br>Parameters:<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr><tr><td><volts></td><td>Float</td><td>Variable</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Calibration Restore Command</td><td>Restores the factory default calibration data. This will reset all self-calibration data resulting from the Calibrate Query that is used to automatically calibrate the zero DC offset, the DC offset adjust scale factor, and the ADC balance.<br><br>Command Syntax<br>CALibration:RESTore<br><br>Query Syntax<br>None<br><br>Parameters:<br>None</td></tr>
<tr><td>Calibration Skew Command<br><br>Calibration Skew Query</td><td>Sets or queries the channel-to-channel timing skew from input channels 1-and-2 to input channels 3-and-4 (1&2 to 3&4). The following considerations apply when using the calibration skew command:<br><br>• Channel-to-channel skew between Inputs 1 and 2 are fixed in hardware and not adjustable. Channel-to-channel skew between Inputs 3 and 4 are fixed in hardware and not adjustable.<br><br>• Channel-to-channel skew between the two pairs of channels (1&2 to 3&4) is adjustable to enable corrections for cabling or circuit delay mismatches.<br><br>• The magnitude of the skew adjustment must be less than one ADC sample interval.<br><br>• Positive skew values add delay to Inputs 1&2 relative to Inputs 3&4. Negative skew values add delay to Inputs 3&4 relative to Inputs 1&2.<br><br>Command Syntax<br>CALibration:SKEW <seconds><br><br>Query Syntax<br>CALibration:SKEW? → <seconds><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><seconds></td><td>Float</td><td>-300 ps to +300 ps<br>MINimum -300 ps<br>MAXimum 300 ps<br><br>Resolution: 10 ps</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Clock Frequency Command<br><br>Clock Frequency Query</td><td>
Sets or queries the sample clock frequency in Hertz. The maximum internal sample clock frequency varies depending upon the product option as shown in the following table.
<table>
<tr><th>Product Option</th><th>2 Channel Maximum Sample Rate</th><th>4 Channel Maximum Sample Rate</th></tr>
<tr><td>ZT412-2X</td><td>500 MS/s</td><td>250 MS/s</td></tr>
<tr><td>ZT412-5X</td><td>400 MS/s</td><td>200 MS/s</td></tr>
</table>
The following considerations apply when setting the clock frequency:
<ul>
<li>A frequency must be entered when using an external sample clock in order to setup timing parameters.</li>
<li>Whenever a frequency changes for an external sample clock, the new frequency must be entered after the external clock has settled at the new frequency.</li>
</ul>
Command Syntax<br>
[SENSe]:SWEep:CLOCk:FREQuency <hertz><br><br>
Query Syntax<br>
[SENSe]:SWEep:CLOCk:FREQuency? → <hertz><br><br>
Parameters
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><hertz></td><td>Float</td><td>Internal Sample Clock:<br>10 kS/s to 4-Channel Maximum Sample Rate<br>in 1, 2.5, 4 and 5 steps<br>500 MS/s, 2 channel interleaved (ZT412-2X)<br>400 MS/s, 2 channel interleaved (ZT412-5X)<br><br>External Sample Clock:<br>40 MS/s to 2-Channel Maximum Sample Rate<br>2 channels enabled: sample at external frequency<br>4 channels enabled: sample at half external frequency</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Clock Source Command<br><br>Clock Source Query</td><td>Sets or queries the selected sample clock source. Internal generator or external input sample clock sources are supported.<br><br>Note: An external clock source must be present before setting to external clock.<br><br>Command Syntax<br>[SENSe]:SWEep:CLOCk:SOURce <source><br><br>Query Syntax<br>[SENSe]:SWEep:CLOCk:SOURce? → <source><br><br>Parameters<br><table><tr><td>Name</td><td>Type</td><td>Range</td><td></td></tr><tr><td><source></td><td>Discrete</td><td>INTernal<br>EXTernal</td><td>Internal Sample Clock<br>External Sample Clock</td></tr></table></td></tr>
<tr><td>Format Byte Command<br><br>Format Byte Query</td><td>Sets of returns the current byte order setting. Normal byte order is MSB first. Swapped byte order is LSB first.<br><br>Command Syntax<br>FORMat:BORDer <order><br><br>Query Syntax<br>FORMat:BORDer? → <order><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td><td></td></tr><tr><td><order></td><td>Discrete</td><td>SWAPped<br>NORMal</td><td>Swapped byte order (LSB first)<br>Normal byte order (MSB first)</td></tr></table></td></tr>
<tr><td>Initiate Command<br><br>Initiate Query</td><td>Initiates the instrument. While initiated, the instrument is enabled to acquire waveforms and perform calculations and measurements.<br><br>Command Syntax<br>INITiate[:IMMediate]<br><br>Query Syntax<br>INITiate?<br><br>Parameters:<br>None</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Initiate Continuous Command<br><br>Initiate Continuous Query</td><td>Sets or returns the instrument initiate continuous state. This is usually only used for limit and mask tests.<br><br>Command Syntax<br>INITiate:CONTinuous <state><br><br>Query Syntax<br>INITiate:CONTinuous? → <state><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><state></td><td>Discrete</td><td>ON or 1 Initiate continuous ON<br>OFF or 0 Initiate continuous OFF</td></tr>
</table>
</td></tr>
<tr><td>Input Attenuation Command<br><br>Input Attenuation Query</td><td>Sets or queries the external attenuation for an input signal. The attenuation feature allows the user to set voltage levels using non-attenuated values.<br><br>Command Syntax<br>[SENSe]:INPut<n>:ATTenuation <atten><br><br>Query Syntax<br>[SENSe]:INPut<n>:ATTenuation? → <atten><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Input Channel 1<br>2 Input Channel 2<br>3 Input Channel 3<br>4 Input Channel 4</td></tr>
<tr><td><atten></td><td>Float</td><td>0.9 to 1000.0<br>MINimum 0.9<br>MAXimum 1000.0</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Input Coupling Command<br><br>Input Coupling Query</td><td>Sets or queries the input signal coupling. The signal coupling feature allows the user to selectively pass or block the DC component of an input signal. The following considerations apply when using the input coupling command:<br><br>• DC coupling passes all frequencies equally<br><br>• AC coupling blocks low frequencies.<br><br>• AC coupling and input impedance setting interact to set the low frequency cutoff frequency. AC and high input impedance attenuates frequencies below 10 Hz. AC coupling and low input impedance attenuates frequencies below 200 kHz.<br><br>• When switching to AC coupling, ensure that the signal has settled before capturing waveform data. With high input impedance, the 10 Hz cutoff requires more than 0.7 seconds to reject a DC signal and to settle within 0.1% of 0.0 VDC.<br><br>Command Syntax<br>[SENSe]:INPut<n>:COUPling <coupling><br><br>Query Syntax<br>[SENSe]:INPut<n>:COUPling? → <coupling><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><n></td><td>U16</td><td>1 Input Channel 1<br>2 Input Channel 2<br>3 Input Channel 3<br>4 Input Channel 4</td></tr>
<tr><td><coupling></td><td>Discrete</td><td>AC AC coupling<br>DC DC coupling</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Input Impedance Command<br><br>Input Impedance Query</td><td>Sets or queries the input impedance in ohms.<br><br>Note: When setting the input impedance, set a temporary level first to preclude setting an incompatible impedance range. Set the range to 10.0V (which is valid for both low and high impedances) before changing the value to the new setting.<br><br>Command Syntax<br>[SENSe]:INPut<n>:IMPedance <ohms><br><br>Query Syntax<br>SENSe]:INPut<n>:IMPedance? → <ohms><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>1 Input Channel 1<br>2 Input Channel 2<br>3 Input Channel 3<br>4 Input Channel 4</td></tr><tr><td><ohms></td><td>Float</td><td>50 or 1e6<br>MINimum 50 ohms (Low impedance)<br>MAXimum 1e6 ohms (High impedance)</td></tr></table></td></tr>
<tr><td>Input State Command<br><br>Input State Query</td><td>Enables or disables an input channel capture.<br><br>Command Syntax<br>[SENSe]:INPut<n>[:STATe] <state><br><br>Query Syntax<br>[SENSe]:INPut<n>[:STATe]? → <state><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>1 Input Channel 1<br>2 Input Channel 2<br>3 Input Channel 3<br>4 Input Channel 4</td></tr><tr><td><state></td><td>Discrete</td><td>ON or 1 Input channel capture ON<br>OFF or 0 Input channel capture OFF</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Input Voltage Offset Command<br><br>Input Voltage Offset Query</td><td>Sets or queries the specified input channel voltage offset. The limits upon the input voltage range.<br><br>Command Syntax<br>[SENSe]:VOLTage<n>:RANGe:OFFSet <volts><br><br>Query Syntax<br>[SENSe]:VOLTage<n>:RANGe:OFFSet? → <volts><br><br>Parameters:
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><n></td><td>U16</td><td>1 Input Channel 1<br>2 Input Channel 2<br>3 Input Channel 3<br>4 Input Channel 4</td></tr>
<tr><td><volts></td><td>Float</td><td>Offset in Volts, See table<br>MINimum<br>MAXimum</td></tr>
</table>
<table>
<tr><th>Impedance</th><th>Range</th><th>Offset</th></tr>
<tr><td>1 MΩ</td><td>50 Vpp</td><td>0V</td></tr>
<tr><td></td><td>25 Vpp</td><td>±12.5V</td></tr>
<tr><td></td><td>10 Vpp</td><td>±5V</td></tr>
<tr><td></td><td>5 Vpp</td><td>±5V</td></tr>
<tr><td></td><td>2.5 Vpp</td><td>±5V</td></tr>
<tr><td></td><td>1.25 Vpp</td><td>±5V</td></tr>
<tr><td></td><td>0.5 Vpp</td><td>±5V</td></tr>
<tr><td></td><td>0.25 Vpp</td><td>±5V</td></tr>
<tr><td>50Ω</td><td>10 Vpp</td><td>0V</td></tr>
<tr><td></td><td>5 Vpp</td><td>±2.5V</td></tr>
<tr><td></td><td>2 Vpp</td><td>±1V</td></tr>
<tr><td></td><td>1 Vpp</td><td>±1V</td></tr>
<tr><td></td><td>0.5 Vpp</td><td>±1V</td></tr>
<tr><td></td><td>0.25 Vpp</td><td>±1V</td></tr>
<tr><td></td><td>0.1 Vpp</td><td>±1V</td></tr>
<tr><td></td><td>0.05 Vpp</td><td>±1V</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Input Voltage Protection State Command<br><br>Input Voltage Protection State Query</td><td>Sets or queries the specified input channel voltage protection state.<br><br>Command Syntax<br>[SENSe]:VOLTage<n>:PROTection[:STATe] <state><br><br>Query Syntax<br>[SENSe]:VOLTage<n>:PROTection[:STATe]? → <state><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>1 Input Channel 1<br>2 Input Channel 2<br>3 Input Channel 3<br>4 Input Channel 4</td></tr><tr><td><state></td><td>Discrete</td><td>ON or 1 Input channel voltage protection ON<br>OFF or 0 Input channel voltage protection OFF</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Input Voltage Range Command<br><br>Input Voltage Range Query</td><td>Sets or queries the specified input channel voltage range. The limits upon the input voltage offset setting are dependent upon the input voltage range.<br><br>Command Syntax<br>[SENSe]:VOLTage<n>:RANGe:PTPeak <volts><br><br>Query Syntax<br>[SENSe]:VOLTage<n>:RANGe:PTPeak? → <volts><br><br>Parameters:
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Input Channel 1<br>2 Input Channel 2<br>3 Input Channel 3<br>4 Input Channel 4</td></tr>
<tr><td><volts></td><td>Float</td><td>Range in Volts, See table<br>MINimum<br>MAXimum</td></tr>
</table>
<table>
<tr><th>Impedance</th><th>Range</th><th>Offset</th></tr>
<tr><td>1 MΩ</td><td>50 Vpp</td><td>0V</td></tr>
<tr><td></td><td>25 Vpp</td><td>±12.5V</td></tr>
<tr><td></td><td>10 Vpp</td><td>±5V</td></tr>
<tr><td></td><td>5 Vpp</td><td>±5V</td></tr>
<tr><td></td><td>2.5 Vpp</td><td>±5V</td></tr>
<tr><td></td><td>1.25 Vpp</td><td>±5V</td></tr>
<tr><td></td><td>0.5 Vpp</td><td>±5V</td></tr>
<tr><td></td><td>0.25 Vpp</td><td>±5V</td></tr>
<tr><td>50Ω</td><td>10 Vpp</td><td>0V</td></tr>
<tr><td></td><td>5 Vpp</td><td>±2.5V</td></tr>
<tr><td></td><td>2 Vpp</td><td>±1V</td></tr>
<tr><td></td><td>1 Vpp</td><td>±1V</td></tr>
<tr><td></td><td>0.5 Vpp</td><td>±1V</td></tr>
<tr><td></td><td>0.25 Vpp</td><td>±1V</td></tr>
<tr><td></td><td>0.1 Vpp</td><td>±1V</td></tr>
<tr><td></td><td>0.05 Vpp</td><td>±1V</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure AC High-Precision Query</td><td>Queries the high-precision AC RMS level of the selected waveform source. This measurement increases the measurement accuracy of waveform records having more than 8-bit resolution, such as averaged waveforms. The added precision requires approximately 10X processing time. The added precision is most noticeable when there is a non-zero input offset adjustment.<br><br>Root-mean-square (RMS) refers to the most common mathematical method of defining the effective voltage or current of an AC wave. This method subtracts the AC voltage average before computing the RMS value.<br><br>For a true sine wave, the rms value is 0.707 times the peak value, or 0.354 times the peak-to-peak value.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:AC? <source> → <volts><br><br>Parameters
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure AC RMS Query</td><td>Queries the AC RMS level of the selected waveform source.<br><br>Root-mean-square (rms) refers to the most common mathematical method of defining the effective voltage or current of an AC wave. This method subtracts the AC voltage average before computing the RMS value.<br><br>For a sine wave, the rms value is 0.707 times the peak value, or 0.354 times the peak-to-peak value.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:AC? <source> → <volts><br><br>Parameters<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Amplitude Query</td><td>Queries the amplitude of the selected waveform source. The amplitude measurement assumes a bi-level signal with distinct high and low levels and is defined as (waveform high level – waveform low level). Use the Measure Peak-to-Peak Voltage Query to detect signal amplitude without assuming a bi-level signal.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:AMPLitude? <source> → <volts><br><br>Parameters
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Average Voltage Query</td><td>Queries the average level of the selected waveform source. The average is defined as the sum of all the sample values in the waveform record divided by the number of samples.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:AVERage? <source> → <volts><br><br>Parameters<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Cycle Average Query</td><td>Queries the average level of one cycle of the selected waveform source. This is always the first cycle seen.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:CAVerage? <source> → <volts><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Cycle Frequency Query</td><td>Queries the frequency for one cycle of the waveform. This is always the first cycle seen.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:CFRequency? <source> → <frequency><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><frequency></td><td>Float</td><td>Frequency in Hertz</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Cycle Period Query</td><td>Queries the period for one cycle of the waveform. This is always the first cycle seen.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:CPERiod? <source> → <seconds><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><seconds></td><td>Float</td><td>Time in seconds</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Cycle RMS Query</td><td>Queries the voltage RMS for one cycle of the waveform, measured from mid-point to mid-point. This is always the first cycle seen.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:CRMS? <source> → <volts><br><br>Parameters:<br><table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr>
</table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure DC High-Precision RMS Query</td><td>Queries the high-precision DC RMS level of the selected waveform source. This measurement increases the measurement accuracy of waveform records having more than 8-bit resolution, such as averaged waveforms. The added precision requires approximately 10X processing time. The added precision is most noticeable when there is a non-zero input offset adjustment.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:DC? <source> → <volts><br><br>Parameters
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure DC RMS Query</td><td>Queries the DC RMS level of the selected waveform source.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:DC? <source> → <volts><br><br>Parameters<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr></table></td></tr>
<tr><td>Measure Edge Command<br><br>Measure Edge Query</td><td>Sets or queries the waveform edge used in edge-related measurements. A falling or rising edge is selected using a 16-bit unsigned integer value and is used in the following measurement types: rise time, rise crossing time, rise overshoot, rise preshoot, fall time, fall crossing time, fall preshoot, and fall overshoot.<br><br>Command Syntax<br>MEASure:EDGE <edge_num><br><br>Query Syntax<br>MEASure:EDGE? → <edge_num><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><edge_num></td><td>U16</td><td>1 to 65535<br>MINimum 1<br>MAXimum 65535</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Effective Number of Bits Query</td><td>
Performs an effective number of bits measurement upon a frequency-domain waveform such as a FFT calculate channel.<br><br>
Effective Number of Bits (ENOB) provides a measure of the input signal dynamic range as if the signal were converted with an ideal analog-to-digital converter (ADC). ENOB provides the number of bits of an ideal ADC that would result in quantization noise equivalent to the sum of all input signal noise and distortion sources. ENOB is directly related to SINAD by the following equation:<br><br>
ENOB = (SINAD – 1.763) / 6.02<br><br>
This measurement is expressed in bits and is a positive value.<br><br>
An invalid measurement code will be returned if the input sinusoidal fundamental cannot be resolved from the noise level. An invalid measurement code will also be returned if this measurement is attempted upon a non-frequency domain waveform, as identified by the waveform preamble header.<br><br>
Due to the quantization level of the fixed point processing algorithm for this measurement, the three lowest-value codes in a frequency domain waveform (-32768, -32767, -32766) are not counted as signal, noise, or harmonics while performing the measurement.<br><br>
Returned Format: The measurement is returned as a positive numeric value representing the measured effective number of bits.<br><br>
Command Syntax<br>
None<br><br>
Query Syntax<br>
MEASure:VOLTage:ENOB? <source> → <bits><br><br>
Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><bits></td><td>Float</td><td>Number of bits</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Fall Crossing Time Query</td><td>Queries time of the falling edge of a waveform crossing the middle reference threshold measured from the start of the waveform. The edge number is selectable.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:FTCRoss? <source> → <seconds><br><br>Parameters:
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><seconds></td><td>Float</td><td>Time in seconds</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Fall Overshoot Query</td><td>Queries the voltage overshoot of the selected waveform. The following considerations apply when using the Measure Fall Overshoot Time Query:<br><br>• Overshoot is defined as the amount of voltage past the low level of a bi-level signal that a signal travels as it transitions from its high state to its low state.<br><br>• Overshoot is calculated as the (signal minimum voltage – low level voltage)/signal amplitude.<br><br>• The value returns as a percent in a decimal. For example, a 10 percent overshoot will be returned as 0.1.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:FOVershoot? <source> → <percent><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><percent></td><td>Float</td><td>0.0 (0 percent) to 1.0 (100 percent)</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Fall Preshoot Query</td><td>Queries the voltage preshoot of the selected waveform. The following considerations apply when using the measure preshoot query:<br><br>• Preshoot is defined as the amount of voltage past the high level of a bi-level signal that a signal travels as it transitions from its high state to its low state.<br><br>• Preshoot is calculated as the signal maximum voltage – high level voltage/signal amplitude.<br><br>• The value returns as a percent in a decimal. For example, a 10 percent preshoot will be returned as 0.1.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:FPReshoot? <source> → <percent><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><percent></td><td>Float</td><td>0.0 (0 percent) to 1.0 (100 percent)</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Fall Time Query</td><td>
Queries the fall time of the selected waveform. Fall time is the time it takes the falling edge of a pulse to go from the upper threshold (high reference) to the lower threshold (low reference).<br><br>
fall time = low cross time – high cross time<br><br>
Returned Format: The measurement is returned as a numeric value representing measured fall time in seconds.<br><br>
Command Syntax<br>None<br><br>
Query Syntax<br>MEASure:VOLTage:FTIMe? <source> → <seconds><br><br>
Parameters:
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><seconds></td><td>Float</td><td>Time in seconds</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Frequency Query</td><td>Queries the frequency of the selected waveform source. All cycles in the entire capture window are used.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:FREQuency? <source> → <frequency><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><frequency></td><td>Float</td><td>Frequency in Hertz</td></tr>
</table>
</td></tr>
<tr><td>Measure Gate Points Command<br><br>Measure Gate Points Query</td><td>Sets or queries the measurement of the selected waveform source using gate start and stop points.<br><br>Command Syntax<br>MEASure:GATE:POINts <start_points>,<stop_points><br><br>Query Syntax<br>MEASure:GATE:POINts? → <start_points>,<stop_points><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><start_points></td><td>U32</td><td>0 to Maximum waveform size<br>MINimum 0<br>MAXimum Maximum waveform size</td></tr>
<tr><td><stop_points></td><td>U32</td><td>0 to Maximum waveform size<br>MINimum 0<br>MAXimum Maximum waveform size</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Gate Time Command<br><br>Measure Gate Time Query</td><td>Sets or queries the measurement of the selected waveform source using gate start and stop times relative to the trigger time.<br><br>Command Syntax<br>MEASure:GATE[:TIME] <gate_start>,<gate_stop><br><br>Query Syntax<br>MEASure:GATE[:TIME]? → <gate_start>,<gate_stop><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><gate_start></td><td>Float</td><td>0 to Maximum waveform size<br>MINimum 0<br>MAXimum Maximum waveform size</td></tr><tr><td><gate_stop></td><td>Float</td><td>0 to Maximum waveform size<br>MINimum 0<br>MAXimum Maximum waveform size</td></tr></table></td></tr>
<tr><td>Measure High Voltage Query</td><td>Queries the high voltage level of the selected waveform source. The high voltage level measurement assumes a bi-level signal with distinct high and low levels and is defined as the waveform upper level. Use the Measure Maximum Voltage Query to detect the most positive waveform voltage level without assuming a bi-level signal.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:HIGH? <source> → <volts><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Low Voltage Query</td><td>Queries the low voltage level of the selected waveform source. The low voltage level measurement assumes a bi-level signal with distinct high and low levels and is defined as the waveform lower level. Use the Measure Minimum Voltage Query to detect the most negative waveform voltage level without assuming a bi-level signal.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:LOW? <source> → <volts><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Maximum Voltage Query</td><td>Queries the most positive voltage of the selected waveform source. The maximum level measurement is defined as the waveform most positive voltage level. Use the Measure High Voltage Query to detect the upper level in a bi-level signal such as a square wave.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:MAXimum? <source> → <volts><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Method Command<br><br>Measure Method Query</td><td>Sets or queries the method to use for measurements. The following method types are available on the ZT412:<br><br><u>Entire Waveform</u><br><br>Entire Waveform measurement is used to perform measurements upon the entire captured waveform.<br><br><u>Gated by Time</u><br><br>Gated by Time measurement is used to perform measurements upon a waveform, where the user defines a start time and stop time. “0” represents the start of the waveform.<br><br><u>Gated by Points</u><br><br>Gated by Points measurement is used to perform measurements on a waveform, where the user defines a start point and stop point. “0” represents the start of the waveform.<br><br>Command Syntax<br>MEASure:METHod <method><br><br>Query Syntax<br>MEASure:METHod? → <method><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td colspan="2">Range</td></tr>
<tr><td><method></td><td>Discrete</td><td>ALL<br>GATE</td><td>Entire waveform<br>Gated</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Mid Voltage Query</td><td>
Queries the mid level voltage of the selected waveform source. The mid level voltage measurement assumes a bi-level signal with distinct high and low voltage levels and is defined as the waveform mid level.<br><br>
Mid level = (High Level + Low Level)/2<br><br>
Use the Measure Maximum Voltage Query to detect the most positive waveform voltage level, and the Measure Minimum Voltage Query to detect the most negative voltage, without assuming a bi-level signal.<br><br>
Command Syntax<br>
None<br><br>
Query Syntax<br>
MEASure:VOLTage:MID? <source> → <volts><br><br>
Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Minimum Voltage Query</td><td>Queries the most negative voltage of the selected waveform source. The minimum voltage level measurement is defined as the most negative voltage level of the waveform. Use the Measure Low Voltage Query to detect the lower level in a bi-level signal such as a square wave.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:MINimum? <source> → <volts><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr></table></td></tr>
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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Negative Duty Cycle Query</td><td>Queries the percent of a cycle the selected waveform is below the mid voltage value. The threshold is defined as the mid voltage level, or midway between high and low levels.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:NDUTycycle? <source> → <percent><br><br>Parameters:
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><percent></td><td>Float</td><td>0.0 (0 percent) to 1.0 (100 percent)</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Negative Width Query</td><td>Queries the time that the selected waveform is below the mid voltage value. The threshold is defined as the mid voltage level, or midway between high and low levels.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:NWIDth? <source> → <seconds><br><br>Parameters:<br><table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><seconds></td><td>Float</td><td>Time in seconds</td></tr>
</table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Peak-To-Peak Voltage Query</td><td>
The Measure Peak-To-Peak Voltage Query performs a peak-to-peak voltage measurement on the specified source, and then returns the measurement results to the output buffer. The method the instrument uses to determine peak-to-peak voltage is to measure the high and low voltages, and then calculate peak-to-peak voltage as follows:<br><br>
peak-to-peak voltage = high voltage – low voltage<br><br>
Command Syntax<br>
None<br><br>
Query Syntax<br>
MEASure:VOLTage:PTPeak? <source> → <volts><br><br>
Parameters:
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><volts></td><td>Float</td><td>Voltage in Volts</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Period Query</td><td>The Measure Period Query performs a period measurement on the specified source, and then returns the measurement results to the output buffer. The period of the signal (1/frequency) is measured using all cycles in the entire capture window.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:PERiod? <source> → <seconds><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><seconds></td><td>Float</td><td>Time in seconds</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Phase Query</td><td>The Measure Phase Query performs a phase measurement on the specified source. This is a measurement of the phase of a periodic signal at the start of the waveform in radians.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:PHASe? <source> → <phase><br><br>Parameters:<br><table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><phase></td><td>Float</td><td>0 to 2*PI (6.283185307)</td></tr>
</table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Positive Duty Cycle Query</td><td>Queries the percent of a cycle of the selected waveform that is above the mid voltage value. The threshold is defined as the mid voltage level, or midway between high and low levels.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:PDUTycycle? <source> → <percent><br><br>Parameters:<br><table><tr><th>Name</th><th>Type</th><th>Range</th></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><percent></td><td>Float</td><td>0.0 (0 percent) to 1.0 (100 percent)</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Positive Width Query</td><td>Queries the time that the selected waveform is above the mid voltage value. The threshold is defined as the mid voltage level, or midway between high and low levels.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:PWIDth? <source> → <seconds><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><seconds></td><td>Float</td><td>Time in seconds</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Reference Command<br><br>Measure Reference Query</td><td>Sets or queries the high, low, and middle reference levels that are used to take rise time, fall time, fall crossing time, and rise crossing time measurements. Reference levels are configured in relative terms of the percentage of the waveform acquired, or in absolute voltage levels (see the Measure Reference Method Command). By default, the low value is 10% of the waveform, the mid level is 50%, and the high value is 90%.<br><br>Reference levels can be set by either percentage or voltage as follows:<br><br>• Low reference selects the threshold for detection of the input signal low state.<br><br>• Middle reference selects the threshold for detection of the input signal middle level.<br><br>• High reference selects the threshold for detection of the input signal high state.<br><br>• The allowed relative reference values range from 0.0 (0 percent) to 1.0 (100 percent).<br><br>• Absolute reference values are expressed in voltages.<br><br>Command Syntax<br>MEASure:REFerence <low_value>,<mid_value>,<high_value><br><br>Query Syntax<br>MEASure:REFerence? → <low_value>,<mid_value>,<high_value><br><br>Parameters:<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><low_value></td><td>Float</td><td>Variable</td></tr><tr><td><mid_value></td><td>Float</td><td>Variable</td></tr><tr><td><high_value></td><td>Float</td><td>Variable</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Reference Method Command<br><br>Measure Reference Method Query</td><td>Sets or queries the reference method used in waveform voltage analysis. Reference methods are in absolute voltages or relative percentages.<br><br>Command Syntax<br>MEASure:REFerence:METHod <reference_method><br><br>Query Syntax<br>MEASure:REFerence:METHod? → <reference_method><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><reference_method></td><td>Discrete</td><td>ABSolute Absolute voltages<br>RELative Relative percentages</td></tr></table></td></tr>
<tr><td>Measure Rise Crossing Time Query</td><td>Queries time of the rising edge of a waveform crossing the middle reference threshold measured from the start of the waveform. The edge number is selectable.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:RTCRoss? <source> → <seconds><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><seconds></td><td>Float</td><td>Time in seconds</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Rise Overshoot Query</td><td>Queries the voltage overshoot of the selected waveform. The following considerations apply when using the measure fall overshoot query:<br><br>• Overshoot is defined as the amount of voltage past the high level of a bi-level signal that a signal travels as it transitions from its low state to its high state.<br><br>• Overshoot is calculated as the signal (maximum voltage – high level voltage)/signal amplitude.<br><br>• The value returns as a percent in a decimal. For example, a 10 percent overshoot will be returned as 0.1.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:ROVershoot? <source> → <percent><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><percent></td><td>Float</td><td>0.0 (0 percent) to 1.0 (100 percent)</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Rise Preshoot Query</td><td>
Queries the voltage preshoot of the selected waveform. The following considerations apply when using the measure preshoot query:<br><br>
• Preshoot is defined as the amount of voltage past the low level of a bi-level signal that a signal travels as it transitions from its low state to its high state.<br><br>
• Preshoot is calculated as the signal (minimum voltage – low level voltage)/signal amplitude.<br><br>
• The value returns as a percent in a decimal. For example, a 10 percent overshoot will be returned as 0.1.<br><br>
Command Syntax<br>None<br><br>
Query Syntax<br>MEASure:VOLTage:RPReshoot? <source> → <percent><br><br>
Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><percent></td><td>Float</td><td>0.0 (0 percent) to 1.0 (100 percent)</td></tr>
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</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Rise Time Query</td><td>
Performs a rise time measurement one time on the signal present, and then sends the measurement results to the output buffer.<br><br>
Rise time is the time it takes the rising edge of a pulse to go from the lower threshold (low reference) to the upper threshold (high reference).<br><br>
Rise time = high cross time – low cross time<br><br>
Returned Format: The measurement is returned as a numeric value representing measured rise time (in seconds).<br><br>
Command Syntax<br>None<br><br>
Query Syntax<br>MEASure:VOLTage:RTIMe? <source> → <seconds><br><br>
Parameters:
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><seconds></td><td>Float</td><td>Time in seconds</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Signal-to-Noise Ratio Query</td><td>
Performs a signal-to-noise ratio measurement upon a frequency-domain waveform such as a FFT calculate channel.<br><br>
Signal-to-Noise Ratio (SNR) is the ratio of the RMS amplitude of the input signal fundamental to the RMS amplitude of the sum of all non-harmonic noise sources. The input signal is assumed to be a perfect single-frequency sinusoidal signal. All signal components other than the input signal fundamental are considered to be harmonic distortion or noise. SNR does NOT include the first nine (second through tenth-order) harmonics as noise. This measurement is expressed in decibels relative to carrier (dBc).<br><br>
An invalid measurement code will be returned if the input sinusoidal fundamental cannot be resolved from the noise level. An invalid measurement code will also be returned if this measurement is attempted upon a non-frequency domain waveform, as identified by the waveform preamble header.<br><br>
Due to the quantization level of the fixed point processing algorithm for this measurement, the three lowest-value codes in a frequency domain waveform (-32768, -32767, -32766) are not counted as signal, noise, or harmonics while performing the measurement.<br><br>
Returned Format: The measurement is returned as a positive numeric value representing the measured signal-to-noise ratio in decibels relative to carrier (dBc).<br><br>
Command Syntax<br>
None<br><br>
Query Syntax<br>
MEASure:VOLTage:SNR? <source> → <dBc><br><br>
Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><dBc></td><td>Float</td><td>Ratio in dBc</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Signal-to-Noise and Distortion Ratio Query</td><td>
Performs a signal-to-noise and distortion ratio measurement upon a frequency-domain waveform such as a FFT calculate channel.<br><br>
Signal-to-Noise and Distortion Ratio (SINAD) is the ratio of the RMS amplitude of the input signal fundamental to the RMS amplitude of the sum of all noise and distortion sources. The input signal is assumed to be a perfect single-frequency sinusoidal signal. All signal components other than the input signal fundamental are considered to be harmonic distortion or noise. SINAD is equivalent to the RMS sum of SNR and THD. This measurement is expressed in decibels relative to carrier (dBc).<br><br>
An invalid measurement code will be returned if the input sinusoidal fundamental cannot be resolved from the noise level. An invalid measurement code will also be returned if this measurement is attempted upon a non-frequency domain waveform, as identified by the waveform preamble header.<br><br>
Due to the quantization level of the fixed point processing algorithm for this measurement, the three lowest-value codes in a frequency domain waveform (-32768, -32767, -32766) are not counted as signal, noise, or harmonics while performing the measurement.<br><br>
Returned Format: The measurement is returned as a positive numeric value representing the measured signal-to-noise and distortion ratio in decibels relative to carrier (dBc).<br><br>
Command Syntax<br>
None<br><br>
Query Syntax<br>
MEASure:VOLTage:SNDR? <source> → <dBc><br><br>
Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><dBc></td><td>Float</td><td>Ratio in dBc</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Spurious-Free Dynamic Range Query</td><td>
Performs a spurious-free dynamic range measurement upon a frequency-domain waveform such as a FFT calculate channel.<br><br>
Spurious-Free Dynamic Range (SFDR) is the ratio of the RMS amplitude of the input signal fundamental to the RMS amplitude of the largest spurious signal. The spurious signal can be either a harmonic or non-harmonic of the input signal fundamental. The input signal is assumed to be a perfect single-frequency sinusoidal signal. All signal components other than the input signal fundamental are considered to be spurious signals. This measurement is expressed in decibels relative to carrier (dBc).<br><br>
An invalid measurement code will be returned if the input sinusoidal fundamental cannot be resolved from the noise level. An invalid measurement code will also be returned if this measurement is attempted upon a non-frequency domain waveform, as identified by the waveform preamble header.<br><br>
Due to the quantization level of the fixed point processing algorithm for this measurement, the three lowest-value codes in a frequency domain waveform (-32768, -32767, -32766) are not counted as signal, noise, or harmonics while performing the measurement.<br><br>
Returned Format: The measurement is returned as a positive numeric value representing the measured spurious-free dynamic range in decibels relative to carrier (dBc).<br><br>
Command Syntax<br>
None<br><br>
Query Syntax<br>
MEASure:VOLTage:SFDR? <source> → <dBc><br><br>
Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><dBc></td><td>Float</td><td>Ratio in dBc</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Time/Frequency of Maximum Voltage Query</td><td>Returns the time in seconds at which the first maximum voltage occurred on the acquired waveform. Zero seconds corresponds to the first point in the waveform. If the measurement is being performed upon a calculate FFT waveform, the result is the frequency of the maximum magnitude in Hertz.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:TMAXimum? <source> → <seconds><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><seconds></td><td>Float</td><td>Time in seconds</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Time/Frequency of Minimum Voltage Query</td><td>Returns the time at which the first minimum voltage occurred on the acquired waveform. Zero seconds corresponds to the first point in the waveform. If the measurement is being performed upon a calculate FFT waveform, the result is the frequency of the minimum magnitude in Hertz.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>MEASure:VOLTage:TMINimum? <source> → <seconds><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr><tr><td><seconds></td><td>Float</td><td>Time in seconds</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Measure Total Harmonic Distortion Query</td><td>
Performs a total harmonic distortion measurement upon a frequency-domain waveform such as a FFT calculate channel.<br><br>
Total Harmonic Distortion (THD) is the ratio of the RMS amplitude of the sum of the first nine (second through tenth-order) harmonics to the RMS amplitude of the input signal fundamental. The input signal is assumed to be a perfect single-frequency sinusoidal signal. All signal components other than the input signal fundamental are considered to be harmonic distortion or noise. This measurement is expressed in decibels relative to carrier (dBc).<br><br>
An invalid measurement code will be returned if the input sinusoidal fundamental cannot be resolved from the noise level. An invalid measurement code will also be returned if this measurement is attempted upon a non-frequency domain waveform, as identified by the waveform preamble header.<br><br>
Due to the quantization level of the fixed point processing algorithm for this measurement, the three lowest-value codes in a frequency domain waveform (-32768, -32767, -32766) are not counted as signal, noise, or harmonics while performing the measurement.<br><br>
Returned Format: The measurement is returned as a negative numeric value representing the measured total harmonic distortion in decibels relative to carrier (dBc).<br><br>
Command Syntax<br>
None<br><br>
Query Syntax<br>
MEASure:VOLTage:THD? <source> → <dBc><br><br>
Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><dBc></td><td>Float</td><td>Distortion in dBc</td></tr>
</table>
</td></tr>
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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Output ECL Trigger Polarity Command<br><br>Output ECL Trigger Polarity Query</td><td>Sets or queries the unit VXIbus ECLTRGn output driver polarity. The following considerations apply:<br><br>• When positive output polarity is selected, the VXIbus output driver will force logic 1 onto the ECL output when the signal source is active; i.e. for a POSitive polarity setting and an ARM source signal, the ECL trigger line will be logic 1 when the unit is armed.<br><br>• Output driver polarity does not affect VXIbus ECLTRG line sensing used by other unit functions.<br><br>• Each output line polarity is selected individually<br><br>• ECLTRG lines can be sourced and sensed simultaneously.<br><br>Command Syntax<br>OUTPut:ECLTrg<n>:POLarity <polarity><br><br>Query Syntax<br>OUTPut:ECLTrg<n>:POLarity?<br><br>Parameters<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>0 ECLTRG0<br>1 ECLTRG1</td></tr><tr><td><polarity></td><td>Discrete</td><td>POSitive Positive polarity<br>NEGative Negative polarity</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Output ECL Trigger Source Command<br><br>Output ECL Trigger Source Query</td><td>Sets or queries the unit VXIbus ECLTRGn output driver source. The following considerations apply:<br><br>• The output driver may be enabled or disabled and the polarity selected; refer to the OUTPut:ECLTrg<n>:POLarity and OUTPut:ECLTrg<n>:SOURce commands.<br><br>• Each output line source is selected individually<br><br>• ECLTRG lines can be sourced and sensed simultaneously.<br><br>Command Syntax<br>OUTPut:ECLTrg<n>:SOURce <source><br><br>Query Syntax<br>OUTPut:ECLTrg<n>:SOURce?<br><br>Parameters<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><n></td><td>U16</td><td>0 ECLTRG0<br>1 ECLTRG1</td></tr>
<tr><td><source></td><td>Discrete</td><td>TRIGger Trigger event<br>CONStant Constant event<br>OPC Operation complete event<br>ARM Arm event</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Output ECL Trigger State Command<br><br>Output ECL Trigger State Query</td><td>Sets or queries the unit VXIbus ECLTRGn output driver state. The following considerations apply:<ul><li>The output source and polarity are selectable.</li><li>Each output line driver state is selected individually.</li><li>ECLTRG lines can be sourced and sensed simultaneously.</li><li>When OFF, the output remains in an inactive state.</li></ul>Command Syntax<br>OUTPut:ECLTrg<n>[:STATe] <state><br><br>Query Syntax<br>OUTPut:ECLTrg<n>[:STATe]?<br><br>Parameters<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>0 ECLTRG0<br>1 ECLTRG1</td></tr><tr><td><state></td><td>Discrete</td><td>ON or 1 Enable<br>OFF or 0 Disable</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Output Reference Source Command<br><br>Output Reference Source Query</td><td>Sets or queries the unit multi-function front-panel reference output signal source, REF OUT. The reference output can be selected from the following sources:<br><br>• a precision +8V voltage reference<br>• the selected 10 MHz TTL reference oscillator output<br>• a 500 Hz TTL probe compensation output<br>• the TTL Trigger event<br>• a 10 ns TTL pulse at 1 ms repetition interval<br>• the TTL Arm event<br><br>Command Syntax<br>OUTPut:REFerence:SOURce <source><br><br>Query Syntax<br>OUTPut:REFerence:SOURce?<br><br>Parameters<br><table><tr><td>Name</td><td>Type</td><td colspan="2">Range</td></tr><tr><td><source></td><td>Discrete</td><td>VOLTage<br>REFerence<br>COMPensate<br>TRIGger<br>PULSe<br>ARM</td><td>Voltage<br>Reference<br>Compensate<br>Trigger<br>Pulse<br>Arm</td></tr></table></td></tr>
<tr><td>Output Reference State Command<br><br>Output Reference State Query</td><td>Sets or queries the unit output reference state. When disabled, the reference output sources a TTL low signal level.<br><br>Command Syntax<br>OUTPut:REFerence[:STATe] <state><br><br>Query Syntax<br>OUTPut:REFerence[:STATe]?<br><br>Parameters<br><table><tr><td>Name</td><td>Type</td><td colspan="2">Range</td></tr><tr><td><state></td><td>Discrete</td><td>ON or 1<br>OFF or 0</td><td>Enable<br>Disable</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Output TTL Trigger Polarity Command<br><br>Output TTL Trigger Polarity Query</td><td>Sets or queries the unit VXIbus TTLTRGn output driver polarity. The following considerations apply:<br><br>• When positive output polarity is selected, the output driver will force logic 0 onto the TTL output when the signal source is active, i.e. for a positive polarity setting and an Arm source signal, the TTL trigger line will be logic 0 when the unit is armed.<br><br>• Output driver polarity does not affect VXIbus TTLTRG line sensing used by other unit functions.<br><br>• Each output line polarity is selected individually<br><br>• TTLTRG lines can be sourced and sensed simultaneously.<br><br>Command Syntax<br>OUTPut:TTLTrg<n>:POLarity <polarity><br><br>Query Syntax<br>OUTPut:TTLTrg<n>:POLarity? → <polarity><br><br>Parameters<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td>TTLTrg<n></td><td>U16</td><td>VXIbus TTL trigger line, where <n> may be 0, 1, 2, 3, 4, 5, 6, or 7</td></tr>
<tr><td><polarity></td><td>Discrete</td><td>NEGative Negative polarity<br>POSitive Positive polarity</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Output TTL Trigger Source Command<br><br>Output TTL Trigger Source Query</td><td>Sets or queries the unit VXIbus TTLTRGn output driver source. The following considerations apply:<br><br>• The output driver may be enabled or disabled and the polarity selected.<br><br>• Each output line source is selected individually<br><br>• TTLTRG lines can be sourced and sensed simultaneously.<br><br>Command Syntax<br>OUTPut:TTLTrg<n>:SOURce <source><br><br>Query Syntax<br>OUTPut:TTLTrg<n>:SOURce? → <source><br><br>Parameters<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td>TTLTrg<n></td><td>U16</td><td>VXIbus TTL trigger line, where <n> may be 0, 1, 2, 3, 4, 5, 6, or 7</td></tr>
<tr><td><source></td><td>Discrete</td><td>TRIGger Trigger event<br>CONStant Constant event<br>OPC Operation complete event<br>ARM Arm event</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Output TTL Trigger State Command<br><br>Output TTL Trigger State Query</td><td>Sets or queries the unit VXIbus TTLTRGn output driver state. The following considerations apply:<br><br>• The output source and polarity are selectable.<br><br>• Each output line driver state is selected individually<br><br>• TTLTRG lines can be sourced and sensed simultaneously.<br><br>Command Syntax<br>OUTPut:TTLTrg<n>[:STATe] <state><br><br>Query Syntax<br>OUTPut:TTLTrg<n>[:STATe]? → <state><br><br>Parameters<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td>TTLTrg<n></td><td>U16</td><td>VXIbus TTL trigger line, where <n> may be 0, 1, 2, 3, 4, 5, 6, or 7</td></tr><tr><td><state></td><td>Discrete</td><td>ON or 1 Active state<br>OFF or 0 Inactive state</td></tr></table></td></tr>
<tr><td>Reference Oscillator Source Command<br><br>Reference Oscillator Source Query</td><td>Sets or queries the source for the 10 MHz reference clock that provides the instrument time base.<br><br>Command Syntax<br>[SENSe]:ROSCillator:SOURce <source><br><br>Query Syntax<br>[SENSe]:ROSCillator:SOURce? → <source><br><br>Parameters:<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><source></td><td>Discrete</td><td>INTernal Local reference selected<br>VXI VXI reference selected</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Calibration Condition Query</td><td>
Queries the contents of the Questionable Calibration Condition Register, represented by <condition> in the parameters below. The Questionable Calibration Condition Register identifies current questionable results from all internally-generated calibration conditions. The following considerations apply when using the Status Calibration Condition Query:<br><br>
• The Questionable Calibration Condition Register identifies current conditions. Use the Status Questionable Calibration Event Query to identify a history of which calibration conditions have failed since the last event status check.<br><br>
• The Status Questionable Calibration Condition Query does not clear the Questionable Calibration Condition Register.<br><br>
Command Syntax<br>None<br><br>
Query Syntax<br>STATus:QUEStionable:CALibration:CONDition? → <condition><br><br>
Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><condition></td><td>U16</td><td>0 to 65535<br>Bit 0 Calibration storage failed<br>Bit 1 Zero DC Offset cal failed<br>Bit 2 DC Offset calibration failed<br>Bit 3 ADC Null balance cal failed<br>Bit 4 ADC Gain balance cal failed<br>Bit 5 Sample rate null cal failed<br>Bits 6–15 Unused</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Calibration Enable Command<br><br>Status Calibration Enable Query</td><td>Sets or queries the contents of the Questionable Calibration Enable Register. The Questionable Calibration Enable Register enables the reporting of questionable calibration events to the Questionable Summary Register. The following considerations apply when using the Status Calibration Enable Command/Query:<br><br>• The Questionable Calibration Enable Register is a bit mask that allows selected questionable calibration events to be reported to the Questionable Summary Register.<br><br>• Only low to high (inactive to active) Questionable Calibration Enable Register bit transitions are reported.<br><br>• Questionable calibration events are reported in bit 8 of the Questionable Summary Register.<br><br>• The Status Preset Command sets all 15 LSBs to one (1) which enables all event reporting.<br><br>Command Syntax<br>STATus:QUEStionable:CALibration:ENABle <enable><br><br>Query Syntax<br>STATus:QUEStionable:CALibration:ENABle? → <enable><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><enable></td><td>U16</td><td>0 to 65535<br>Bit 0 Calibration storage failed<br>Bit 1 Zero DC Offset cal failed<br>Bit 2 DC Offset calibration failed<br>Bit 3 ADC Null balance cal failed<br>Bit 4 ADC Gain balance cal failed<br>Bit 5 Sample rate null cal failed<br>Bits 6–15 Unused</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Calibration Event Query</td><td>
Queries the Questionable Calibration Event Register. The Questionable calibration Event Register identifies calibration processes that have completed with questionable results. The following considerations apply when using the Status Calibration Event Query:
<ul>
<li>The Questionable Calibration Event Register records the history of the questionable calibration process results generated since the previous Questionable Calibration Event Query.</li>
<li>The Status Questionable Event Query clears the Questionable Frequency Event Register after returning the current register contents.</li>
<li>Questionable calibration events are reported in bit 8 of the Questionable Summary Register.</li>
<li>In order to identify questionable results from a particular process, the Questionable Calibration Event Register must be cleared by reading it before the processes are run.</li>
</ul>
Command Syntax<br>None<br><br>
Query Syntax<br>STATus:QUEStionable:CALibration [:EVENt]? → <event><br><br>
Parameters:
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><event></td><td>U16</td><td>0 to 65535<br>Bit 0 Calibration storage failed<br>Bit 1 Zero DC Offset cal failed<br>Bit 2 DC Offset calibration failed<br>Bit 3 ADC Null balance cal failed<br>Bit 4 ADC Gain balance cal failed<br>Bit 5 Sample rate null cal failed<br>Bits 6–15 Unused</td></tr>
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</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Frequency Condition Query</td><td>Queries the contents of the Questionable Frequency Condition Register, represented by <condition> in the parameters below. The Questionable Frequency Condition Register identifies current questionable results from all internally-generated clock frequency conditions. The following considerations apply when using the Status Frequency Condition Query:<br><br>• The Questionable Frequency Condition Register identifies current conditions. Use the Status Questionable Frequency Event Query to identify a history of which frequency conditions have failed since the last event status check.<br><br>• The Status Frequency Condition Query does not clear the Questionable Frequency Condition Register.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>STATus:QUEStionable:FREQuency:CONDition? → <condition><br><br>Parameters<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><condition></td><td>U16</td><td>0 to 65535<br>Bit 0 PLL Unlocked<br>Bits 1–15 Unused</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Frequency Enable Command<br><br>Status Frequency Enable Query</td><td>Sets or queries the contents of the Questionable Frequency Enable Register. The Questionable Frequency Enable Register enables the reporting of questionable frequency events to the Questionable Summary Register. The following considerations apply when using the Status Frequency Enable Command/Query:<br><br>• The Questionable Frequency Enable Register is a bit mask that allows selected questionable frequency events to be reported to the Questionable Summary Register.<br><br>• Only low to high (inactive to active) Questionable Frequency Enable Register bit transitions are reported.<br><br>• Questionable frequency events are reported in bit 5 of the Questionable Summary Register.<br><br>• The Status Preset Command sets all 15 LSBs to one (1), which enables all event reporting.<br><br>Command Syntax<br>STATus:QUEStionable:FREQuency:ENABle <enable><br><br>Query Syntax<br>STATus:QUEStionable:FREQuency:ENABle? → <enable><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><enable></td><td>U16</td><td>0 to 65535<br>Bit 0 PLL Unlocked<br>Bits 1–15 Unused</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Frequency Event Query</td><td>Queries the Questionable Frequency Event Register. The Questionable Frequency Event Register identifies frequency processes that have completed with questionable results. The following considerations apply when using the Status Frequency Event Query:<br><br>• The Questionable Frequency Event Register records the history of the questionable frequency process results generated since the previous questionable frequency event query.<br><br>• The Status Questionable Event Query clears the Questionable Frequency Event Register after returning the current register contents.<br><br>• Questionable frequency events are reported in bit 5 of the Questionable Summary Register.<br><br>• In order to identify questionable results from a particular process, the Questionable Frequency Event Register must be cleared by reading it before the processes are run.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>STATus:QUEStionable:FREQuency[:EVENt]? → <event><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><event></td><td>U16</td><td>0 to 65535<br>Bit 0 PLL Unlocked<br>Bit 0 PLL Unlocked<br>Bits 1–15 Unused</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Operation Condition Query</td><td>Queries the contents of the Operation Status Condition Register. The Operation Status Condition Register identifies currently running processes, such as waveform acquisition. The following considerations apply when using the Status Operation Condition Query:<br><br>• The Operation Status Condition Register identifies current running processes. Use the Status Operation Event Query to identify a history of which processes have run since the last operation event status check.<br><br>• The Status Operation Condition Query does not clear the Operation Status Condition Register<br><br>Command Syntax<br>None<br><br>Query Syntax<br>STATus:OPERation:CONDition? → <condition><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><condition></td><td>U16</td><td>0 to 65535<br>Bit 0 Calibrating<br>Bit 1 Settling<br>Bit 2 Ranging<br>Bit 3 Sweeping<br>Bit 4 Measuring<br>Bit 5 Waiting for trigger<br>Bit 6 Waiting for arm<br>Bit 7 Unused<br>Bit 8 Trigger event<br>Bit 9 Data capture event<br>Bit 10 Limit test event<br>Bits 11–15 Unused</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Operation Enable Command<br><br>Status Operation Enable Query</td><td>Sets or queries the contents of the Operation Status Enable Register. The Operation Status Enable Register enables the reporting of operation events to the Status Byte. The following considerations apply when using the Status Operation Enable Command/Query:<br><br>• The Operation Status Enable Register is a bit mask that allows selected operation status events to be reported to the Status Byte.<br><br>• Only low to high (inactive to active) Operation Status Event Register bit transitions are reported.<br><br>• Operation status events report in bit 7 of the Status Byte.<br><br>• The Status Preset Command sets all register bits to zero (0), which disables all operation event reporting.<br><br>Command Syntax<br>STATus:OPERation:ENABle <enable><br><br>Query Syntax<br>STATus:OPERation:ENABle? → <enable><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><enable></td><td>U16</td><td>0 to 65535<br>Bit 0 Calibrating<br>Bit 1 Settling<br>Bit 2 Ranging<br>Bit 3 Sweeping<br>Bit 4 Measuring<br>Bit 5 Waiting for trigger<br>Bit 6 Waiting for arm<br>Bit 7 Unused<br>Bit 8 Trigger event<br>Bit 9 Data capture event<br>Bit 10 Limit test event<br>Bits 11–15 Unused</td></tr>
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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Operation Event Query</td><td>
Queries the contents of the Operation Event Status Register. The Operation Event Status Register identifies unit processes that have been run, such as waveform acquisition. The following considerations apply when using the Status Operation Event Query:
<ul>
<li>The Operation Event Status Register records the history of the processes that have been run since the previous operation event status query. Use the Status Operation Condition Query to identify currently running processes</li>
<li>The Status Operation Event Query clears the Operation Status Event Register after returning the current register contents</li>
<li>Operation Status Event Register bits may be summarized in the Status Byte.</li>
<li>In order to identify which processes have run between two times, ex. acquisition start and later status check, the Operation Event Status Register must be cleared by reading it before the processes are run.</li>
</ul>
Command Syntax<br>None<br><br>
Query Syntax<br>STATus:OPERation[:EVENt]? → <event><br><br>
Parameters:
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><event></td><td>U16</td><td>0 to 65535<br>Bit 0 Calibrating<br>Bit 1 Settling<br>Bit 2 Ranging<br>Bit 3 Sweeping<br>Bit 4 Measuring<br>Bit 5 Waiting for trigger<br>Bit 6 Waiting for arm<br>Bit 7 Unused<br>Bit 8 Trigger event<br>Bit 9 Data capture event<br>Bit 10 Limit test event<br>Bits 11–15 Unused</td></tr>
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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Preset Command</td><td>Sets the status reporting event enable data structures to a known state. The condition and event register contents are not affected. All device-dependent status registers which cascade events into the Questionable Status and the Operation Status Registers are enabled by setting those device-dependent event enable registers to $7FFF_{16}$ (the 15 LSBs set). The IEEE-488.2 mandatory status data structures are disabled by setting the Questionable Status and Operation Status event enable registers to $0000_{16}$. The Status Byte and Standard Event Status Registers as defined by IEEE 488.2 are not affected.<br><br>Command Syntax<br>STATus:PRESet<br><br>Query Syntax<br>None<br><br>Parameters:<br>None</td></tr>
<tr><td>Status Questionable Condition Query</td><td>Queries the contents of the Questionable Status Condition Register. The Questionable Status Condition Register identifies current questionable results from running processes, such as self-test. The following considerations apply when using the questionable condition status query:<br><br>• The Questionable Status Condition Register identifies current questionable results from running processes. Use the Status Questionable Event Query to identify which questionable results generated since the last questionable event status check.<br><br>• The Status Questionable Condition Query does <u>not</u> clear the Questionable Status Condition Register<br><br>Command Syntax<br>None<br><br>Query Syntax<br>STATus:QUEStionable:CONDition? → <condition><br><br>Parameters:<br><table><tr><th>Name</th><th>Type</th><th>Range</th></tr><tr><td><condition></td><td>U16</td><td>0 to 65535<br>Bit 0 Voltage bit<br>Bits 1–4 Unused<br>Bit 5 Frequency bit<br>Bits 6–7 Unused<br>Bit 8 Calibration bit<br>Bit 9 Test bit<br>Bits 10–15 Unused</td></tr></table></td></tr>
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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Questionable Enable Command<br><br>Status Questionable Enable Query</td><td>Sets or queries the contents of the Questionable Status Enable Register. The Questionable Status Enable Register enables the reporting of questionable events to the Status Byte. The following considerations apply when using the Status Questionable Enable Command/Query:<br><br>• The Questionable Status Enable Register is a bit mask that allows selected questionable status events to be reported to the Status Byte.<br><br>• Only low to high (inactive to active) Questionable Status Event Register bit transitions are reported.<br><br>• Questionable status events are reported in bit 3 of the Status Byte. Refer to the Status Byte query.<br><br>• Status Preset Command sets all register bits to zero (0) which disables all questionable event reporting.<br><br>Command Syntax<br>STATus:QUEStionable:ENABle <enable><br><br>Query Syntax<br>STATus:QUEStionable:ENABle? → <enable><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><enable></td><td>U16</td><td>0 to 65535<br>Bit 0 Voltage bit<br>Bits 1–4 Unused<br>Bit 5 Frequency bit<br>Bits 6–7 Unused<br>Bit 8 Calibration bit<br>Bit 9 Test bit<br>Bits 10–15 Unused</td></tr>
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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Questionable Event Query</td><td>Queries the Questionable Status Event Register. The Questionable Event Status Register identifies unit processes that have completed with questionable results, such as self test errors. The following considerations apply when using the Status Questionable Event Query:<br><br>• The Questionable Status Event Register records the history of the questionable process results generated since the previous questionable event status query.<br><br>• The Status Questionable Event query clears the Questionable Status Event Register after returning the current register contents.<br><br>• Questionable Status Event Register bits may be summarized in the Status Byte.<br><br>• In order to identify questionable results from a particular process, the Questionable Status Event Register must be cleared by reading it before the processes are run.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>STATus:QUEStionable[:EVENt]? → <event><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><event></td><td>U16</td><td>0 to 65535<br>Bit 0 Voltage bit<br>Bits 1–4 Unused<br>Bit 5 Frequency bit<br>Bits 6–7 Unused<br>Bit 8 Calibration bit<br>Bit 9 Test bit<br>Bits 10–15 Unused</td></tr>
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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Test Condition Query</td><td>
Queries the contents of the Questionable Test Condition Register. The Questionable Test Condition Register identifies the test results of memory (RAM, DRAM, and Flash) tests, along with register and PLL tests. The following considerations apply when using the Status Test Condition Query:<br><br>
• The Questionable Test Condition Register identifies current tests. Use the Status Questionable Test Condition Query to identify a history of which tests have failed since the last test status check.<br><br>
• Questionable test events report in bit 9 of the Questionable Summary Register.<br><br>
• The Status Questionable Test Condition Query does not clear the Questionable Test Condition Register.<br><br>
Command Syntax<br>None<br><br>
Query Syntax<br>STATus:QUEStionable:TEST:CONDition? → <condition><br><br>
Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><condition></td><td>U16</td><td>0 to 65535<br>Bit 0 Baseboard test failed<br>Bit 1 SRAM test failed<br>Bit 2 ROM test failed<br>Bit 3 Unused<br>Bit 4 Ref oscillator test failed<br>Bit 5 DRAM test failed<br>Bit 6 Flash memory test failed<br>Bit 7 Unused<br>Bit 8 Input1–2 register test failed<br>Bit 9 Input1 RAM test failed<br>Bit 10 Input2 RAM test failed<br>Bit 11 PLL test failed<br>Bit 12 Input3–4 register test failed<br>Bit 13 Input3 RAM test failed<br>Bit 14 Input4 RAM test failed<br>Bit 15 Unused</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Test Enable Command<br><br>Status Test Enable Query</td><td>
Sets or queries the contents of the Questionable Test Status Register. The Questionable Test Status Register enables the reporting of questionable events to the Status Byte. The following considerations apply when using the Status Test Enable Command/Query:
<ul>
<li>The Questionable Test Status Register is a bit mask that allows selected questionable self-test events to be reported to the Status Byte.</li>
<li>Only low to high (inactive to active) Questionable Test Status Register bit transitions are reported.</li>
<li>Questionable test status events report in bit 9 of the Questionable Summary Register.</li>
<li>The Status Preset Command sets the 15 LSB enable register bits to “1”, which enables all test event reporting.</li>
</ul>
Command Syntax<br>
STATus:QUEStionable:TEST:ENABle <enable><br><br>
Query Syntax<br>
STATus:QUEStionable:TEST:ENABle? → <enable><br><br>
Parameters:
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><enable></td><td>U16</td><td>0 to 65535<br>Bit 0 Baseboard test failed<br>Bit 1 SRAM test failed<br>Bit 2 ROM test failed<br>Bit 3 Unused<br>Bit 4 Ref oscillator test failed<br>Bit 5 DRAM test failed<br>Bit 6 Flash memory test failed<br>Bit 7 Unused<br>Bit 8 Input1–2 register test failed<br>Bit 9 Input1 RAM test failed<br>Bit 10 Input2 RAM test failed<br>Bit 11 PLL test failed<br>Bit 12 Input3–4 register test failed<br>Bit 13 Input3 RAM test failed<br>Bit 14 Input4 RAM test failed<br>Bit 15 Unused</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Test Event Query</td><td>
Queries the Questionable Test Status Register. The Questionable Test Status Register identifies unit self tests that have completed with questionable results, such as self test errors. The following considerations apply when using the Status Test Event Query:
<ul>
<li>The Questionable Test Status Register records the history of the questionable process results generated since the previous questionable event status query.</li>
<li>The Status Questionable Event Query clears the Questionable Status Event Register after returning the current register contents.</li>
<li>Questionable Test Status Event Register reports in bit 9 of the Questionable Summary Register.</li>
<li>In order to identify questionable results from a particular process, the Questionable Status Event Register must be cleared by reading it before the processes are run.</li>
</ul>
Command Syntax<br>None<br><br>
Query Syntax<br>STATus:QUEStionable:TEST[:EVENt]? → <event><br><br>
Parameters:
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><event></td><td>U16</td><td>0 to 65535<br>Bit 0 Baseboard test failed<br>Bit 1 SRAM test failed<br>Bit 2 ROM test failed<br>Bit 3 Unused<br>Bit 4 Ref oscillator test failed<br>Bit 5 DRAM test failed<br>Bit 6 Flash memory test failed<br>Bit 7 Unused<br>Bit 8 Input1–2 register test failed<br>Bit 9 Input1 RAM test failed<br>Bit 10 Input2 RAM test failed<br>Bit 11 PLL test failed<br>Bit 12 Input3–4 register test failed<br>Bit 13 Input3 RAM test failed<br>Bit 14 Input4 RAM test failed<br>Bit 15 Unused</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Voltage Condition Query</td><td>Queries the contents of the Questionable Voltage Condition Register. The Questionable Voltage Condition Register identifies the voltage overages for the input channels. The following considerations apply when using the Status Voltage Condition Query:<br><br>• The Questionable Voltage Condition Register identifies voltage overloads. Use the Status Questionable Voltage Condition Query to identify a history of which voltages have had overloads since the last voltage status check.<br><br>• Questionable voltage events report in bit 0 of the Questionable Summary Register.<br><br>• The Status Questionable Voltage Condition Query does not clear the Questionable Voltage Condition Register.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>STATus:QUEStionable:VOLTage:CONDition? → <condition><br><br>Parameters:<br><table><tr><th>Name</th><th>Type</th><th>Range</th></tr><tr><td><condition></td><td>U16</td><td>0 to 65535<br>Bit 0 Input1 overload<br>Bit 1 Input2 overload<br>Bit 2 Input3 overload<br>Bit 3 Input4 overload<br>Bit 4 Input1 overvoltage<br>Bit 5 Input2 overvoltage<br>Bit 6 Input3 overvoltage<br>Bit 7 Input4 overvoltage<br>Bits 8–15 Unused</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Voltage Enable Command<br><br>Status Voltage Enable Query</td><td>Sets or queries the contents of the Questionable Voltage Status Register. The Questionable Voltage Status Register enables the reporting of questionable events to the Status Byte. The following considerations apply when using the Status Voltage Enable Command/Query:<br><br>• The Questionable Voltage Status Register is a bit mask that allows selected questionable voltage overload and over voltage events to be reported to the Status Byte.<br><br>• Only low to high (inactive to active) Questionable Voltage Status Register bit transitions are reported.<br><br>• Questionable voltage status events report in bit 0 of the Questionable Summary Register.<br><br>• The Status Preset Command sets the 15 LSB enable register bits to “1”, which enables all voltage overload and over voltage reporting.<br><br>Command Syntax<br>STATus:QUEStionable:VOLTage:ENABle <enable><br><br>Query Syntax<br>STATus:QUEStionable:VOLTage:ENABle? → <enable><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><enable></td><td>U16</td><td>0 to 65535<br>Bit 0 Input1 overload<br>Bit 1 Input2 overload<br>Bit 2 Input3 overload<br>Bit 3 Input4 overload<br>Bit 4 Input1 overvoltage<br>Bit 5 Input2 overvoltage<br>Bit 6 Input3 overvoltage<br>Bit 7 Input4 overvoltage<br>Bits 8–15 Unused</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Status Voltage Event Query</td><td>Queries the Questionable Voltage Status Register. The Questionable Voltage Status Register identifies unit voltage overloads and over voltages that have completed with questionable results. The following considerations apply when using the Status Voltage Event Query:<br><br>• The Questionable Voltage Status Register records the history of the questionable process results generated since the previous questionable event status query.<br><br>• The Status Questionable Event Query clears the Questionable Status Event Register after returning the current register contents.<br><br>• Questionable Voltage Status Event Register reports in bit 0 of the Questionable Summary Register.<br><br>• In order to identify questionable results from a particular process, the Questionable Status Event Register must be cleared by reading it before the processes are run.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>STATus:QUEStionable:VOLTage [:EVENt]? → <event><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><event></td><td>U16</td><td>0 to 65535<br>Bit 0 Input1 overload<br>Bit 1 Input2 overload<br>Bit 2 Input3 overload<br>Bit 3 Input4 overload<br>Bit 4 Input1 overvoltage<br>Bit 5 Input2 overvoltage<br>Bit 6 Input3 overvoltage<br>Bit 7 Input4 overvoltage<br>Bits 8–15 Unused</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Sweep Mode Command<br><br>Sweep Mode Query</td><td>Sets or queries the trigger mode to enable automatic triggering in absence of a trigger event.<br><br>Command Syntax<br>[SENSe]:SWEep:MODE <trigger_mode><br><br>Query Syntax<br>[SENSe]:SWEep:MODE? → <trigger_mode><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td colspan="2">Range</td></tr><tr><td><trigger_mode></td><td>Discrete</td><td>AUTO<br>NORMal</td><td>Automatic triggering<br>Normal triggering</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Sweep Offset Reference Command<br><br>Sweep Offset Reference Query</td><td>Sets or queries the waveform record offset reference location. The following considerations apply:<br><br>• The waveform offset reference can be considered a “handle” on the record. The waveform offset reference location is the location of the handle relative to the start of the waveform record.<br><br>• The offset reference is used by the Sweep Offset Time Command to move the record relative to the trigger event.<br><br>• An offset reference value of 0.0 places the handle at the first point of the record; a value of 0.5 selects the mid point; and a value of 1.0 selects the last point.<br><br>• When the offset time is set to 0.0, a reference location of 0.0 will place the trigger event at the waveform record start, a reference location of 1.0 will place the trigger event at the waveform record end.<br><br>• All captured waveforms use the same offset reference.<br><br>Command Syntax<br>[SENSe]:SWEep:OREFerence:LOCation <percent><br><br>Query Syntax<br>[SENSe]:SWEep:OREFerence:LOCation? → <percent><br><br>Parameters:<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><percent></td><td>Float</td><td>0.0 (0 percent) to 1.0 (100 percent)<br>MINimum 0.0 (start of waveform)<br>MAXimum 1.0 (end of waveform)</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Sweep Offset Time Command<br><br>Sweep Offset Time Query</td><td>
Sets or queries the time between the sweep offset reference and the trigger event. The following considerations apply when using the sweep offset time command:
<ul>
<li>The offset time is the time between the trigger event and the offset reference, refer to the Sweep Offset Reference Command for more information on the offset reference.</li>
<li>Offset times move the offset reference after the trigger event.</li>
<li>The time of the last sample taken may be calculated as:<br><br>Last Sample Time = offset time + sweep time * (1 – offset reference location)</li>
<li>All channels use the same sweep offset time</li>
</ul>
Command Syntax<br>
[SENSe]:SWEep:OFFSet:TIME <seconds><br><br>
Query Syntax<br>
[SENSe]:SWEep:OFFSet:TIME? → <seconds><br><br>
Parameters:
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><seconds></td><td>Float</td><td>0 to 655 seconds<br>Resolution: See table below</td></tr>
</table>
Resolution:
<table>
<tr><td>Resolution</td><td>Time in Seconds</td></tr>
<tr><td>10 ns</td><td>0 to 655.36 µs</td></tr>
<tr><td>100 ns</td><td>655.36 µs to 6.5536 ms</td></tr>
<tr><td>1 µs</td><td>6.5536 ms to 65.536 ms</td></tr>
<tr><td>10 µs</td><td>65.536 ms to 655.36 ms</td></tr>
<tr><td>100 µs</td><td>655.36 ms to 6.5536s</td></tr>
<tr><td>1 ms</td><td>6.5536s to 65.536s</td></tr>
<tr><td>10 ms</td><td>65.536s to 655 s</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Sweep Points Command<br><br>Sweep Points Query</td><td>
Sets or queries the number of samples in a waveform record. The range of points varies with the size of the installed digitizer memory. The following considerations apply when using the sweep points command:<br><br>
• The minimum record length is 100 data points.<br><br>
• The maximum record length is the size of the digitizer memory. The maximum record size is further limited by the number of active channels.<br><br>
• When in 4 channel mode, each channel may use up to half of the full digitizer memory size. When using two-channel interleaved mode, each of two channels may use up to the full digitizer memory size.<br><br>
Note: The capture circuitry requires a small number of samples in the digitizer memory for housekeeping. At maximum waveform sizes, bad samples may be returned at the beginning of the waveform record.<br><br>
• Use the Sweep Rate Query to read the current sample rate in samples per second.<br><br>
• All active channels share the same record length setting.<br><br>
Command Syntax<br>
[SENSe]:SWEep:POINts <points><br><br>
Query Syntax<br>
[SENSe]:SWEep:POINts? → <points><br><br>
Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><points></td><td>U32</td><td>100 to N, where N is the maximum memory size<br>MINimum 100<br>MAXimum Maximum memory size</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Sweep Time Query</td><td>Queries the time span or duration of the waveform acquisition gate. The following considerations apply when using the sweep time query:<br><br>• The minimum sweep time is 50 ns; the maximum sweep time is N/10 KS/s, where N is the maximum memory.<br><br>• All channels share the same sweep time span.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>[SENSe]:SWEep:TIME? → <seconds><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><seconds></td><td>Float</td><td>50 ns to N/10 KS/s, where N is the maximum memory<br>MINimum 50 ns<br>MAXimum N/10 KS/s, where N is the maximum memory</td></tr>
</table>
</td></tr>
<tr><td>System Delay Bypass Command<br><br>System Delay Bypass Query</td><td>Sets or queries the system delay bypass condition. The system delay causes wait states on the instrument to allow specific hardware changes to settle when control commands are issued. This ensures that the instrument hardware is at the proper state before returning from the control command. When bypassed, the wait state is disabled and the hardware may not have settled to its new condition when the instrument returns from the control command. This command is not recommended under normal operating conditions. The delay bypass state is always reset (delay enabled) upon a Reset Command.<br><br>Command Syntax<br>SYSTem:DELay:BYPass <state><br><br>Query Syntax<br>SYSTem:DELay:BYPass? → <state><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><state ></td><td>Discrete</td><td>ON or 1 Active State (delay bypassed)<br>OFF or 0 Inactive state (delay enabled)</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>System Error All Query</td><td>Returns all 32 entries in the error log and clears the error log. Multiple errors are stored sequentially in the error log with the oldest error first. A zero value is returned for all non-error entries when there are less than 32 errors stored in the error log.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>SYSTem:ERRor:ALL? → <error_number><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><error_number></td><td>S16</td><td>0 to –32768<br>0 No error<br><br>Note: See Appendix 3, Error Table, for a description of errors.</td></tr></table></td></tr>
<tr><td>System Error Count Query</td><td>Returns the number of errors in the error log.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>SYSTem:ERRor:COUNt? → <error_count><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><error_count></td><td>U16</td><td>0 to 32</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>System Error Query</td><td>Returns and clears the first entry in the error log. Multiple errors are stored sequentially in the error log with the oldest error first. A zero value is returned if there are no errors in the log.<br><br>Note: This command is not recommended for new applications. Use System Error All Query instead.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>SYSTem:ERRor[:NEXT]? → <error><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><error></td><td>S16</td><td>0 to –32768<br>0 No error<br><br>Note: See Appendix 3, Error Table, for a description of errors.</td></tr>
</table>
</td></tr>
<tr><td>System Memory Query</td><td>Returns the total available waveform memory for use by the four digitizer channels.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>SYSTem:MEMory? → <size><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><size></td><td>U32</td><td>Memory Options<br>4 MSamples Total<br>64 MSamples Total<br><br>Note: Total samples must be equal to the installed memory option.</td></tr>
</table>
</td></tr>
</table>

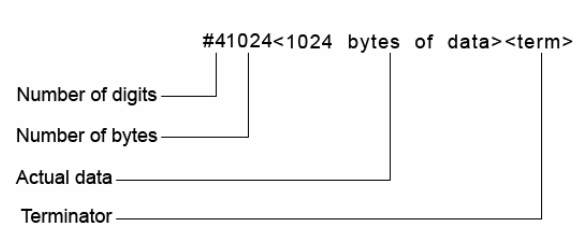


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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>System Version Query</td><td>Returns the SCPI version to which the instrument complies.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>SYSTem:VERSion? → <version><br><br>Parameters:<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><version></td><td>Float</td><td>Variable</td></tr></table></td></tr>
</table>



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| Name | Description |
|---|---|
| **Trace Data Command**<br><br>**Trace Data Query** | Reads or writes waveform data to the instrument using the word-serial interface. This command is used to download waveform data from Input Channels 1–4 (INPut<n>) or Calculate Channels 1-2 (CALCulate<n>), and to load or download waveform data to/from Reference Channels 1-4 (REFerence<n>).<br><br>Data Interchange Format data (DIF_data) is definite-length block response data. DIF_data allows any type of device-dependent data to be transmitted over the system interface as a series of 8-bit binary data types. It is especially useful for sending large quantifies of data or 8-bit extended ASCII codes. DIF_data uses a specific syntax, a pound sign (#) followed by a non-zero digit representing the number of digits in the decimal integer. After the non-zero digit is the decimal integer that states the number of 8-bit data bytes sent. This is followed by the actual data. The following is an example for writing 1024 bytes of data:<br><br><br><br><br>**Command Syntax**<br>TRACe[:DATA] <destination>, DIF_data<br><br>**Query Syntax**<br>TRACe[:DATA]? <source> → DIF_data<br><br>**Parameters:**<br><br>Name \| Type \| Range<br><destination> \| Discrete \| REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><source> \| Discrete \| INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1<br>DIF_data \| S16 \| Binary Data |



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trace Copy Reference Command</td><td>Stores the reference waveform in nonvolatile memory.<br><br>Command Syntax<br>TRACe:COPY:REFerence<n> <source><br><br>Query Syntax<br>None<br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Reference Channel 1<br>2 Reference Channel 2<br>3 Reference Channel 3<br>4 Reference Channel 4</td></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trace Load Calculate Query</td><td>Queries calculate channel waveform data using the VXI A32 space. The data starting at the offset location in the waveform (wave_offset) with size (length) is loaded into the A32 memory address (mem_addr). The instrument returns a “1” in response to the query when it has moved all of the data into the A32 memory.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>TRACe:LOAD:CALCulate<n>? <wave_offset>, <mem_addr>, <length><br>→ “1”<br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>1 Calculation Channel 1<br>2 Calculation Channel 2</td></tr><tr><td><wave_offset></td><td>U32</td><td>0 to 32768 (maximum calculate waveform size)</td></tr><tr><td><mem_addr></td><td>U32</td><td>0 to 67108864 (maximum A32 memory size)</td></tr><tr><td><length></td><td>U32</td><td>0 to 32768 (maximum calculate waveform size)</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trace Load Input Query</td><td>Queries input channel waveform data using the VXI A32 space. The data starting at the offset location in the waveform (wave_offset) with size (length) is loaded into the A32 memory address (mem_addr). The instrument returns a “1” in response to the query when it has moved all of the data into the A32 memory.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>TRACe:LOAD:INPut<n>? <wave_offset>, <mem_addr>, <length> → “1”<br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>1 Input Channel 1<br>2 Input Channel 2<br>3 Input Channel 3<br>4 Input Channel 4</td></tr><tr><td><wave_offset></td><td>U32</td><td>0 to 33554432 (maximum input waveform size)</td></tr><tr><td><mem_addr></td><td>U32</td><td>0 to 67108864 (maximum A32 memory size)</td></tr><tr><td><length></td><td>U32</td><td>0 to 33554432 (maximum input waveform size)</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trace Load Reference Command<br><br>Trace Load Reference Query</td><td>Read or write the reference channel waveform data using the VXI A32 space. When querying (downloading) data from the instrument, the data starting at the offset location in the waveform (wave_offset) with size (length) is loaded into the A32 memory address (mem_addr). The instrument returns a “1” in response to the query when it has moved all of the data into the A32 memory. When writing (loading) data to the instrument, the data must be loaded into the A32 space before issuing this command. The data starting at the offset location in the waveform (wave_offset) with size (length) must be loaded into the A32 memory address (mem_addr).<br><br>Note: Use Trace Preamble Command/Query to read/write the appropriate time and voltage conversion factors.<br><br>Command Syntax<br>TRACe:LOAD:REFerence<n> <wave_offset>, <mem_addr>, <length><br><br>Query Syntax<br>TRACe:LOAD:REFerence<n>? <wave_offset>, <mem_addr>, <length> → “1”<br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><n></td><td>U16</td><td>1 Reference Channel 1<br>2 Reference Channel 2<br>3 Reference Channel 3<br>4 Reference Channel 4</td></tr>
<tr><td><wave_offset></td><td>U32</td><td>0 to 32768 (maximum reference waveform size)</td></tr>
<tr><td><mem_addr></td><td>U32</td><td>0 to 67108864 (maximum A32 memory size)</td></tr>
<tr><td><length></td><td>U32</td><td>0 to 32768 (maximum reference waveform size)</td></tr>
</table>
</td></tr>
<tr><td>Trace Preamble Command<br><br>Trace Preamble Query</td><td>Reads or writes the waveform trace preamble to the unit. The Trace Preamble is an ordered syntax of values. The values are shown below.<br><br>• Source: Selects the source to read the waveform preamble from.<br><br>• Type: Returns the type of acquisition used.<br><br>• Points: Returns the number of points in a waveform.<br><br>• Count: Returns the acquired waveform count used to create the selected average or envelope waveform. In Normal acquisition the Acquisition Count is always 1.<br><br>• Time Interval: Returns the time interval between points.</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td></td><td>
<ul>
<li>Time Offset: Returns the time in seconds of the first data point relative to the trigger.</li>
<li>Voltage Interval: Returns the voltage resolution.</li>
<li>Voltage Offset: Returns the zero-voltage reference or DC offset voltage for the specified waveform.</li>
</ul>
Command Syntax<br>
TRACe:PREamble <source> <type>, <points>, <count>, <time_interval>, <time_offset>, <voltage_interval>, <voltage_offset><br><br>
Query Syntax<br>
TRACe:PREamble? <source> <type>, <points>, <count>, <time_interval>, <time_offset>, <voltage_interval>, <voltage_offset> → “1”<br><br>
Parameters:
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n><br>Input channels, where <n> may be 1, 2, 3, or 4. Example: INP1.<br><br>REFerence<n><br>Reference channels, where <n> may be 1, 2, 3, or 4. Example: REF1.<br><br>CALCulate<n><br>Calculate channels, where <n> may be 1 or 2. Example: CALC1</td></tr>
<tr><td><type></td><td>U16</td><td>0 = Invalid waveform<br>1 = Normal voltage-time waveform<br>2 = Averaged voltage-time waveform<br>3 = Envelope waveform<br>4 = Equivalent Time waveform<br>16 = Frequency Domain waveform</td></tr>
<tr><td><points></td><td>U32</td><td>0 to maximum memory</td></tr>
<tr><td><count></td><td>U16</td><td>1 to 2048</td></tr>
<tr><td><time_interval></td><td>Float</td><td>Time in seconds</td></tr>
<tr><td><time_offset></td><td>Float</td><td>Time in seconds</td></tr>
<tr><td><voltage_interval></td><td>Float</td><td>Voltage in Volts</td></tr>
<tr><td><voltage_offset></td><td>Float</td><td>Voltage in Volts</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger A Event Count Command<br><br>Trigger A Event Count Query</td><td>Sets or queries the number of events that Trigger A must count before it enables other waveform capture functions. The following considerations apply when using the Trigger A Event Count Command:<br><br>• The event count affects the capture cycle as follows:<br><br>o Arm<br>o Count trigger events<br>o When the event count is reached, Trigger A will:<br>▪ Enable Trigger B detection<br>▪ Enable the sweep timer<br>o End the capture cycle and begin post-capture processing<br><br>• The event counter uses the output of the trigger qualifier as an event source (Refer to the Trigger A Pattern Command, Trigger A Pulse High Limit Command, Trigger A Pulse Low Limit Command, Trigger A Slope Command, Trigger A Source Command, and the Trigger A Type Command for information on configuring trigger qualifier parameters).<br><br>Command Syntax<br>TRIGger[:A]:ECOunt <count><br><br>Query Syntax<br>TRIGger[:A]:ECOunt? → <count><br><br>Parameters:<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><count></td><td>U16</td><td>1 to 65535<br>MINimum 1<br>MAXimum 65535</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger A Pulse High Limit Command<br><br>Trigger A Pulse High Limit Query</td><td>Sets or queries the upper pulse width limit. The instrument triggers when the pulse width is greater than or less than the upper limit value. For example, to trigger when the pulse width is greater than 50 ns, set the upper limit to 50 ns. The instrument triggers when the pulse width is greater than 50 ns.<br><br>Note: Pulse high limit and pulse low limit use the same resolution for pulse width in and pulse width out when both limits are used.<br><br>Command Syntax<br>TRIGger[:A]:PULSe:HLIMit <seconds><br><br>Query Syntax<br>TRIGger[:A]:PULSe:HLIMit? → <seconds><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><seconds></td><td>Float</td><td>20 ns to 655 seconds<br>Resolution: see table below</td></tr>
</table>
<br>Resolution:<br><br>
<table>
<tr><td>Resolution</td><td>Time in Seconds</td></tr>
<tr><td>10 ns</td><td>20 ns to 655.36 µs</td></tr>
<tr><td>100 ns</td><td>655.36 µs to 6.5536 ms</td></tr>
<tr><td>1 µs</td><td>6.5536 ms to 65.536 ms</td></tr>
<tr><td>10 µs</td><td>65.536 ms to 655.36 ms</td></tr>
<tr><td>100 µs</td><td>655.36 ms to 6.5536s</td></tr>
<tr><td>1 ms</td><td>6.5536s to 65.536s</td></tr>
<tr><td>10 ms</td><td>65.536s to 655 s</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger A Pulse Low Limit Command<br><br>Trigger A Pulse Low Limit Query</td><td>
Sets or queries the lower pulse width limit. The instrument triggers when the pulse width is less than the lower limit value.<br><br>
Note: Pulse high limit and pulse low limit use the same resolution for pulse width in and pulse width out when both limits are used.<br><br>
Command Syntax<br>
TRIGger[:A]:PULSe:LLIMit <seconds><br><br>
Query Syntax<br>
TRIGger[:A]:PULSe:LLIMit? → <seconds><br><br>
Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><seconds></td><td>Float</td><td>10 ns to 655 seconds<br>Resolution: see table below</td></tr>
</table>
<br>
Resolution:<br><br>
<table>
<tr><td>Resolution</td><td>Time in Seconds</td></tr>
<tr><td>10 ns</td><td>10 ns to 655.36 µs</td></tr>
<tr><td>100 ns</td><td>655.36 µs to 6.5536 ms</td></tr>
<tr><td>1 µs</td><td>6.5536 ms to 65.536 ms</td></tr>
<tr><td>10 µs</td><td>65.536 ms to 655.36 ms</td></tr>
<tr><td>100 µs</td><td>655.36 ms to 6.5536s</td></tr>
<tr><td>1 ms</td><td>6.5536s to 65.536s</td></tr>
<tr><td>10 ms</td><td>65.536s to 655 s</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger A Slope Command<br><br>Trigger A Slope Query</td><td>Sets or queries the active edge of the selected trigger.<br><br>Command Syntax<br>TRIGger[:A]:SLOPe <slope><br><br>Query Syntax<br>TRIGger[:A]:SLOPe? → <slope><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><slope></td><td>Discrete</td><td>POSitive Rising Edge<br>NEGative Falling Edge</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger A Source Command<br><br>Trigger A Source Query</td><td>Sets or queries the Trigger A signal source. The following considerations apply:<br><br>• All sources are assumed to be low-to-high transitioning signals when active. If a source becomes active on a high-to-low transition, use the Trigger A Slope Command to select negative slope.<br><br>• Trigger A detection must complete before Trigger B detector or sweep offset timer are enabled.<br><br>Command Syntax<br>TRIGger[:A]:SOURce <source><br><br>Query Syntax<br>TRIGger[:A]:SOURce? → <source><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th colspan="2">Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n></td><td>Input channels, where <n> may be 1, 2, 3, or 4.</td></tr>
<tr><td></td><td></td><td>EXTernal</td><td>External trigger source</td></tr>
<tr><td></td><td></td><td>TTLTrg<n></td><td>VXIbus TTL trigger line, where <n> may be 0, 1, 2, 3, 4, 5, 6, or 7</td></tr>
<tr><td></td><td></td><td>ECLTrg<n></td><td>VXIbus ECL trigger line, where <n> may be 0 or 1</td></tr>
<tr><td></td><td></td><td>ARM</td><td>Front panel ARM IN signal</td></tr>
<tr><td></td><td></td><td>MANual</td><td>Manual trigger</td></tr>
<tr><td></td><td></td><td>PATTern</td><td>Pattern trigger</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger A Type Command<br><br>Trigger A Type Query</td><td>Sets or queries the Trigger A detection type. The following considerations apply when using the Trigger A type:<br><br>• Six trigger types are accepted: edge, pulse inside limits, pulse outside limits, pulse less than limit, pulse greater than limit, and video.<br><br>• Edge triggering looks for a rising or falling edge from the selected signal source.<br><br>• Pulse inside limits looks for a pulse width greater than a low-time limit and less than or equal to a high-time limit.<br><br>• Pulse outside limits looks for a pulse width less than a low time limit or greater than a high time limit.<br><br>• Pulse less than looks for a pulse width less than a low time limit.<br><br>• Pulse greater than looks for a pulse width greater than a high time limit.<br><br>• Video triggering looks for a specific field or line from the selected source.<br><br>• Trigger A detection must be complete before the Trigger B detector or sweep offset timer are enabled<br><br>Command Syntax<br>TRIGger[:A]:TYPE <type><br><br>Query Syntax<br>TRIGger[:A]:TYPE? → <type><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th colspan="2">Range</th></tr>
<tr><td><type></td><td>Discrete</td><td>EDGE</td><td>Edge trigger</td></tr>
<tr><td></td><td></td><td>PIN</td><td>Pulse inside limits</td></tr>
<tr><td></td><td></td><td>POUT</td><td>Pulse outside limits</td></tr>
<tr><td></td><td></td><td>PLTHan</td><td>Pulse less than</td></tr>
<tr><td></td><td></td><td>PGTHan</td><td>Pulse greater than</td></tr>
<tr><td></td><td></td><td>VIDeo</td><td>Video trigger</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger A Video Field Command<br><br>Trigger A Video Field Query</td><td>Sets or queries which video field to select a line to trigger on.<br><br>Command Syntax<br>TRIGger[:A]:VIDeo:FIELd <field><br><br>Query Syntax<br>TRIGger[:A]:VIDeo:FIELd? → <field><br><br>Parameters:<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><field></td><td>U16</td><td>1 or 2</td></tr></table></td></tr>
<tr><td>Trigger A Video Line Command<br><br>Trigger A Video Line Query</td><td>Sets or queries which video line to trigger on.<br><br>Note: Range depends on video standard and field.<br><br>Command Syntax<br>TRIGger[:A]:VIDeo:LINE <line><br><br>Query Syntax<br>TRIGger[:A]:VIDeo:LINE? → <line><br><br>Parameters:<br><br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><line></td><td>U16</td><td><u>NTSC</u><br>Field 1: 1 to 263<br>MINimum 1<br>MAXimum 263<br><br>Field 2: 1 to 262<br>MINimum 1<br>MAXimum 262<br><br><u>PAL/SECAM</u><br>Field 1: 1 to 313<br>MINimum 1<br>MAXimum 313<br><br>Field 2: 314 to 625<br>MINimum 314<br>MAXimum 625</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger A Video Standard Command<br><br>Trigger A Video Standard Query</td><td>Sets or queries the video standard.<br><br>Command Syntax<br>TRIGger[:A]:VIDeo:STANdard <video_standard><br><br>Query Syntax<br>TRIGger[:A]:VIDeo:STANdard? → <video_standard><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><video_standard></td><td>Discrete</td><td>PAL PAL standard<br>NTSC NTSC standard<br>SECam SECAM standard</td></tr>
</table>
</td></tr>
<tr><td>Trigger B Slope Command<br><br>Trigger B Slope Query</td><td>Sets or queries the active edge of the selected trigger.<br><br>Command Syntax<br>TRIGger:B:SLOPe <slope><br><br>Query Syntax<br>TRIGger:B:SLOPe? → <slope><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><slope></td><td>Discrete</td><td>POSitive Rising Edge<br>NEGative Falling Edge</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger B Source Command<br><br>Trigger B Source Query</td><td>Sets or queries the Trigger B signal source. The following considerations apply when using setting the Trigger B source:<br><br>• Trigger B slope is selectable using edge triggering.<br><br>• If a source becomes active on a high-to-low transition, use the Trigger B Slope Command.<br><br>• Trigger A detection must be complete before the Trigger B detector or sweep offset timer are enabled.<br><br>Command Syntax<br>TRIGger:B:SOURce <source><br><br>Query Syntax<br>TRIGger:B:SOURce? → <source><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th colspan="2">Range</th></tr>
<tr><td><source></td><td>Discrete</td><td>INPut<n> may</td><td>Input channels, where <n> be 1, 2, 3, or 4.</td></tr>
<tr><td></td><td></td><td>EXTernal</td><td>External trigger source</td></tr>
<tr><td></td><td></td><td>TTLTrg<n></td><td>VXIbus TTL trigger line, where <n> may be 0, 1, 2, 3, 4, 5, 6, or 7</td></tr>
<tr><td></td><td></td><td>ARM</td><td>Front panel ARM IN signal</td></tr>
<tr><td></td><td></td><td>MANual</td><td>Manual trigger</td></tr>
</table>
</td></tr>
<tr><td>Trigger B State Command<br><br>Trigger B State Query</td><td>Sets or queries the status state of Trigger B.<br><br>Command Syntax<br>TRIGger:B[:STATe] <state><br><br>Query Syntax<br>TRIGger:B[:STATe]? → <state><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th colspan="2">Range</th></tr>
<tr><td><state></td><td>Discrete</td><td>ON or 1<br>OFF or 0</td><td>Enable<br>Disable</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger Hold Off Command<br><br>Trigger Hold Off Query</td><td>Sets or queries the duration (in seconds) to hold off or ignore all other triggers before recognizing the next trigger event.<br><br>Command Syntax<br>TRIGger:HOLDoff <seconds><br><br>Query Syntax<br>TRIGger:HOLDoff? → <seconds><br><br>Parameters:<br><br>
<table>
<tr><td>Name</td><td>Type</td><td>Range</td></tr>
<tr><td><seconds></td><td>Float</td><td>0 to 655 seconds<br>MINimum 0<br>MAXimum 655<br><br>Resolution: see table below</td></tr>
</table>
<br>Resolution:<br><br>
<table>
<tr><td>Resolution</td><td>Time in Seconds</td></tr>
<tr><td>10 ns</td><td>0 to 655.36 µs</td></tr>
<tr><td>100 ns</td><td>655.36 µs to 6.5536 ms</td></tr>
<tr><td>1 µs</td><td>6.5536 ms to 65.536 ms</td></tr>
<tr><td>10 µs</td><td>65.536 ms to 655.36 ms</td></tr>
<tr><td>100 µs</td><td>655.36 ms to 6.5536s</td></tr>
<tr><td>1 ms</td><td>6.5536s to 65.536s</td></tr>
<tr><td>10 ms</td><td>65.536s to 655 s</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger External Level Command<br><br>Trigger External Level Query</td><td>Sets or queries the external trigger input level.<br><br>Command Syntax<br>TRIGger:EXTernal:LEVel <volts><br><br>Query Syntax<br>TRIGgerEXTernal:LEVel? → <volts><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><volts></td><td>Float</td><td>±1 volts<br>MINimum –1 volts<br>MAXimum +1 volts<br><br>Resolution: 0.5 mV</td></tr></table></td></tr>
<tr><td>Trigger Input Level Command<br><br>Trigger Input Level Query</td><td>Sets or queries an analog input channel trigger level. The following considerations apply when setting the input trigger level:<br><br>• The trigger level has the same range as the input range.<br><br>• Each input channel has an independent trigger level.<br><br>• The logic level out of the threshold detector is reported to the Trigger A and B multiplexers for selection as the input trigger sources.<br><br>Command Syntax<br>TRIGger:INPut<n>:LEVel <volts><br><br>Query Syntax<br>TRIGger:INPut<n>:LEVel? → <volts><br><br>Parameters:<br><table><tr><td>Name</td><td>Type</td><td>Range</td></tr><tr><td><n></td><td>U16</td><td>1 Input Channel 1<br>2 Input Channel 2<br>3 Input Channel 3<br>4 Input Channel 4</td></tr><tr><td><volts></td><td>Float</td><td>Input Offset ± $\frac{\text{Input Range}}{2}$</td></tr></table></td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger Pattern Mask Command<br><br>Trigger Pattern Mask Query</td><td>Sets or queries which sources to use in the pattern.<br><br>Command Syntax<br>TRIGger:PATTern:MASK <pattern_mask ><br><br>Query Syntax<br>TRIGger:PATTern:MASK? → <pattern_mask><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><pattern_mask></td><td>U16</td><td>0 to 255<br>0 Do not use in pattern trigger<br>1 Use in pattern trigger<br><br>Source Order (MSB–LSB):<br><br>• Bits 15–8 are ignored<br>• Bit 7—External Arm<br>• Bit 6—VXI ECLTRG1<br>• Bit 5—VXI ECLTRG0<br>• Bit 4—External Trigger<br>• Bit 3—Channel 4<br>• Bit 2—Channel 3<br>• Bit 1—Channel 2<br>• Bit 0—Channel 1</td></tr>
</table>
</td></tr>
</table>



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<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Trigger Pattern Truth Command<br><br>Trigger Pattern Truth Query</td><td>Sets or queries the state of each source for the pattern trigger to occur.<br><br>Command Syntax<br>TRIGger:PATTern:TRUTh <pattern_truth><br><br>Query Syntax<br>TRIGger:PATTern:TRUTh? → <pattern_truth><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><pattern_truth></td><td>U16</td><td>0 to 255<br>0 Low<br>1 High<br><br>Source Order (MSB–LSB):<br><br>• Bits 15–8 are ignored<br>• Bit 7—External Arm<br>• Bit 6—VXI ECLTRG1<br>• Bit 5—VXI ECLTRG0<br>• Bit 4—External Trigger<br>• Bit 3—Channel 4<br>• Bit 2—Channel 3<br>• Bit 1—Channel 2<br>• Bit 0—Channel 1</td></tr>
</table>
</td></tr>
<tr><td>Trigger Timestamp Query</td><td>Returns the trigger timestamp of the most recent trigger event in fractional seconds with a 1 second period.<br><br>Command Syntax<br>None<br><br>Query Syntax<br>TRIGger:TIMestamp? → <seconds><br><br>Parameters:<br><br>
<table>
<tr><th>Name</th><th>Type</th><th>Range</th></tr>
<tr><td><seconds></td><td>Float</td><td>0 to 1 second<br>Resolution: 100 ns</td></tr>
</table>
</td></tr>
</table>



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# Specifications




## Analog Input

| | |
|---|---|
| Channels | Quantity 4 |
| Bandwidth | DC to 250 MHz typical, 200 MHz minimum (50 Ω)<br>DC to 125 MHz typical, 100 MHz minimum (1 MΩ) |
| Slew Rate | 4000 V/µs (50 Ω)<br>800 V/µs (1 MΩ) |
| Maximum Input (50 Ω) | ±5 V (DC + peak AC)<br>Input load protection @ ±6 VDC |
| Maximum Input (1 MΩ) | ±25 V [DC + peak AC (<10 MHz)]<br>Peak AC, de-rated 20 dB/decade above 10 MHz |

Full Scale Input Range & Offset Adjust

| Impedance | Range | Offset |
|---|---|---|
| 1 MΩ | 50 Vpp | 0V |
| | 25 Vpp | ±12.5V |
| | 10 Vpp | ±5V |
| | 5 Vpp | ±5V |
| | 2.5 Vpp | ±5V |
| | 1.25 Vpp | ±5V |
| | 0.5 Vpp | ±5V |
| | 0.25 Vpp | ±5V |
| 50Ω | 10 Vpp | 0V |
| | 5 Vpp | ±2.5V |
| | 2 Vpp | ±1V |
| | 1 Vpp | ±1V |
| | 0.5 Vpp | ±1V |
| | 0.25 Vpp | ±1V |
| | 0.1 Vpp | ±1V |
| | 0.05 Vpp | ±1V |

| | |
|---|---|
| DC Gain Accuracy | < ±0.25% full scale range (50 Ω)<br>< ±0.25% full scale range (1 MΩ) |



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| | |
|---|---|
| Zero DC Offset | < ± (0.25% full scale range + 1 mV) @ +25 °C (50 Ω)<br>< ±(0.25% full scale range + 5 mV) @ +25 °C (1 MΩ) |
| Zero DC Offset Drift | < ± 0.05% maximum offset adjust/°C |
| Offset Adjust Accuracy | < ± 1% |
| Impedance | 1 MΩ \|\| 12 pF or 50 Ω |
| Impedance Accuracy | ± 1% |
| Input VSWR (50 Ω) | ≤ 1.3:1, DC to 50Ω Bandwidth |
| Input Bias (50 Ω) | ≤ ±25 µA (50 Ω)<br>≤ ±1 nA (1 MΩ) |
| Coupling | DC or AC |
| AC Coupling | 200 kHz high pass (50Ω)<br>10 Hz high pass (1 MΩ) |
| Probe Attenuation | 0.9 to 1000:1 |
| RMS Noise | ≤ (0.1% of range + 200 µV) (50 Ω)<br>≤ (0.1% of range + 1.25 mV) (1M Ω) |
| Connectors | BNC |

# Analog-to-Digital Converter

| | |
|---|---|
| Sample Rate | 10 kS/s to 200 MS/s in 1, 2.5, 4, and 5 steps<br>250 MS/s (ZT412-20 only)<br>400 MS/s, 1 channel interleaved<br>500 MS/s, 1 channel interleaved (ZT412-2X only) |

Resolution &
Maximum Sample Rate

| Product Option | ADC Resolution | 1 Channel Maximum Sample Rate | 2 Channel Maximum Sample Rate |
|---|---|---|---|
| **ZT412-2X** | 14-bit | 500 MS/s | 250 MS/s |
| **ZT412-5X** | 16-bit | 400 MS/s | 200 MS/s |

Acquisition Time Range

| Product Option | Minimum Acquisition Time | Maximum Acquisition Time |
|---|---|---|
| **ZT412-2X** | 200 ns | 3,355 seconds |
| **ZT412-5X** | 250 ns | 3,355 seconds |

| | |
|---|---|
| Channel-to-Channel Skew | ≤ 100 ps difference with channels at same input settings |
| Skew Adjust | -300 ps to +300 ps in 10 ps steps (Channels: 1-and-2 to 3-and-4) |



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Dynamic Range
10.7 MHz (Typical)

| 50Ω Input Range (Vpp) | Signal-to Noise Ratio (SNR) | Total Harmonic Distortion (THD) | Signal-to-Noise + Distortion (SINAD) |
|---|---|---|---|
| 1.0 to 10.0 | 74.5 dBc | 70.2 dBc | 68.8 dBc |
| 0.5 | 70.5 dBc | 70.2 dBc | 67.3 dBc |
| 0.25 | 64.5 dBc | 70.5 dBc | 63.5 dBc |
| 0.1 | 56.5 dBc | 70.9 dBc | 56.3 dBc |
| 0.05 | 50.5 dBc | 70.9 dBc | 50.5 dBc |

60.1 MHz (Typical)

| 50Ω Input Range (Vpp) | Signal-to Noise Ratio (SNR) | Total Harmonic Distortion (THD) | Signal-to-Noise + Distortion (SINAD) |
|---|---|---|---|
| 1.0 to 10.0 | 74.5 dBc | 50.1 dBc | 50.1 dBc |
| 0.5 | 70.5 dBc | 50.1 dBc | 50.0 dBc |
| 0.25 | 64.5 dBc | 50.5 dBc | 50.3 dBc |
| 0.1 | 56.5 dBc | 50.8 dBc | 49.8 dBc |
| 0.05 | 50.5 dBc | 50.8 dBc | 47.6 dBc |

**Note**: Dynamic range for interleaved sample rates is degraded by 4 dB for input channels 2 & 4.

# Waveform Memory

| | |
|---|---|
| Total Memory | Up to 8M samples/channel<br>Up to 16M samples/channel (2 channels interleaved) |
| Memory Options | 2M samples total (ZT412-X0)<br>32M samples total (ZT412-X1) |

# Acquisition Modes

| | |
|---|---|
| Types | Normal, Average, Envelope, and Equivalent-Time |
| Channels | Normal & Equivalent-Time: Quantity 4 inputs simultaneous<br>Average & Envelope: Quantity 2 inputs simultaneous |
| Waveform Size | 100 samples to total memory (Normal)<br>100 samples to 32k samples (Average, Envelope, Equivalent-Time) |
| Waveform Count | 2 to 65535 waveforms |
| Averaging | 16-bit waveform averaging resolution |
| Envelope | Minimum and Maximum Envelope |
| Equivalent-Time | High sample rate waveform reconstruction |
| Equivalent-Time Points | 2 to 100 equivalent-time points per real-time point<br>2 to 100 times equivalent-time sample rate |



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# Trigger

| | |
|---|---|
| Trigger Source | Channels 1 to 4, External Trigger, ECLTRG0-1, TTLTRG0–7*, External Arm, Pattern, Software |
| Trigger Slope/Polarity | Positive or Negative |
| Trigger Position | 0% to 100% of waveform time + trigger delay<br>±1 sample interval position accuracy |
| Post-Trigger Delay | 0 to 655 seconds |
| Pre-Trigger Delay | 0 to waveform time |
| Trigger Holdoff | Programmable delay after trigger before recognizing next trigger event |
| Holdoff Range | 0 to 655 seconds |
| Trigger B | Second edge trigger event qualifier |
| Pattern Trigger | Pattern match true or false |
| Pattern Sources | Channels 1 to 4, External Trigger, External Arm, ECLTRG0-1 |
| Event Trigger | Event Counter: 1 to 65535 trigger events |
| Trigger Modes | Edge, Pulse Width, Video |
| Edge Trigger Mode | Rising or Falling Edge |
| Pulse Width Trigger Mode | Triggers on pulse width greater than, less than, or between limits |
| Pulse Width Type | < limit1, > limit1, < limit1 & > limit2 |
| Pulse Width Range | 20 ns to 655 seconds |
| Pulse Width Resolution | 10 ns |
| Video Trigger Mode | PAL (50 Hz), NTSC (60 Hz), SECAM (50 Hz)<br>Standard, Field, Line selectable |
| Ch 1–4 Trigger Level | (offset – full scale/2) to (offset + full scale/2) |
| Ch 1–4 Trigger Sensitivity | 5% of full scale (DC to 75 MHz) |
| Ch 1–4 Trigger Bandwidth | ≥ 200 MHz |
| Ch 1–4 Trigger Hysteresis | 5% (overdrive required) |
| Ch 1–4 Level Resolution | 0.025% of full scale |
| Ch 1–4 Level Accuracy | ±(2% full scale + 5 mV + offset accuracy) |
| Trigger Timestamp | 100 ns resolution, 1 second rollover |



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# External Trigger Input

| | |
|---|---|
| Maximum Input | ±5V, no damage |
| Threshold Input | ±1V |
| Threshold Accuracy | ±20 mV |
| Threshold Resolution | 0.5 mV |
| Input Impedance | 50 Ω ±2% |
| Connector | BNC |

# Trigger Outputs

| | |
|---|---|
| Functionality | Event Output Signals |
| Outputs | TTLTRG0–7*, ECLTRG0–1 |
| Source | Trigger Event, Arm Event, OPC, Constant |

# Reference Output

| | |
|---|---|
| Functionality | reference voltage, ground, trigger event, arm event,<br>10 MHz clock, 500 Hz probe compensation, 10 ns pulse @ 1ms rate |
| Reference Voltage Output | +8 V ± 1% into 10 kΩ load |
| Logic Output (all other types) | TTL Compatible |
| Connector | BNC |

# Arm

| | |
|---|---|
| Functionality | Arm to qualify trigger event |
| Source | External Trigger, External Arm, ECLTRG0-1, TTLTRG0–7*, Software |
| Polarity | Positive or Negative |

# External Arm Input

| | |
|---|---|
| Maximum Input | 0V to 5V, no damage |
| Nominal Level | TTL Compatible |
| Input Impedance | 1 kΩ ±2%, pull-up to +5V |
| Connector | BNC |



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# External Sampling Clock Input

| | |
|---|---|
| Function | External Sampling Clock bypasses Phase Locked Loop,<br>All ADC channels synchronized to external clock |
| Clock Rates | 40 MHz to maximum external clock frequency<br>1 channel enabled: sample at external frequency<br>2 channels enabled: sample at half external frequency |

| Product Option | Maximum Ext Clock Frequency | 1 Channel Maximum Sample Rate | 2 Channel Maximum Sample Rate |
|---|---|---|---|
| **ZT412-2X** | 500 MHz | 500 MS/s | 250 MS/s |
| **ZT412-5X** | 400 MHz | 400 MS/s | 200 MS/s |

| | |
|---|---|
| Maximum Input | ±5V, no damage |
| Input Signal Level | 500 mVpp to 1 Vpp, sine or square wave |
| Input Impedance | AC coupled, 50Ω ±2% |
| Connector | BNC |

# 10 MHz Time Base Reference

| | |
|---|---|
| Clock Source | Internal TCXO, VXI Backplane CLK10 |
| Internal TCXO | ± 2.5 ppm accuracy |

# Data Processing

| | |
|---|---|
| Auto Scale | Automatic adjust to input signals: Input Range, Offset, Sample Rate, Trigger Source, and Trigger Level |
| Self-Calibration | Automatic internal calibration: Input DC Offset Zero, Input DC Offset Adjust Gain, ADC leveling |

# Measurements

| | |
|---|---|
| Measurements | Min, Max, Low, High, Mid, Average, Amplitude, Peak-to-Peak, DC RMS, AC RMS, +Width, –Width, Period, Frequency, +Duty, –Duty, Phase, Rise Time, Rise Overshoot, Rise Preshoot, Rise Crossing Time, Fall Time, Fall Overshoot, Fall Preshoot, Fall Crossing Time, Time of Maximum, Time of Minimum, Cycle Average, Cycle RMS, Cycle Frequency, Cycle Period, AC High-Precision, DC High-Precision, SNR, THD, SINAD, ENOB, SFDR |
| Measurement Methods | Entire Waveform, Gated by Time, Gated by Points |



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| | |
|---|---|
| Measurement Levels | Low, Mid, High reference levels for edge measurements set in absolute voltages or relative percentages |

Measurement Accuracy

| | |
|---|---|
| Delta DC Voltage | ± (DC gain accuracy) |
| Absolute DC Voltage | ± [(DC gain accuracy)+(offset accuracy)] |
| Time | ± (time resolution) |
| Frequency | ± [1/(time resolution)] |

Note: time resolution = one sample interval or one ETS sample interval (for ETS acquisition)

# Reference Waveforms

| | |
|---|---|
| Reference Channels | Quantity 4 |
| Reference Storage | Non-volatile memory storage |
| Reference Size | 32k maximum waveform size |

# Calculations

| | |
|---|---|
| Calculate Channels | Quantity 2 |
| Calculate Size | 32k maximum waveform size |
| Calculate Functions | Add, Subtract, Multiply, Copy, Invert, Integral, Derivative, Absolute Value, Limit Test, Mask Test, Frequency Transform, Time Transform |
| Limit Test | Measurement Limit Range Testing or Waveform Mask Testing |
| Limit Test Reports | Measurement maximum, minimum, average, current value, pass/fail counts |
| Frequency Transform | FFT Magnitude |
| FFT Windowing | Rectangular, Hamming, Hanning, Blackman |
| Time Transform | Infinite Impulse Response (IIR) filtering |
| IIR Filter Count | 2 to 40 data points |

# Instrument Setup Storage

| | |
|---|---|
| Reset | Non-volatile storage of default instrument setup configuration |
| Save & Recall | Non-volatile storage of 31 instrument setup configurations |



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# Data Interface

| | |
|---|---|
| VXIbus Connection | Standard P1 and P2 interface |
| Command Interface | A16 SCPI message-based |
| Interrupt Operation | Programmable interrupter, Level 1–7 |
| Data Interface | 64MB A32 register-based |
| Manufacturer ID | 3712 ($E80_{16}$) |
| Model Code | 412 ($19C_{16}$) |

# VXIbus P2 Trigger & Clock Pin Usage

| | | |
|---|---|---|
| Pin A1 | ECLTRG0 | (ECL level bidirectional) |
| Pin A3 | ECLTRG1 | (ECL level bidirectional) |
| Pin A23 | TTLTRG0* | (TTL level bidirectional) |
| Pin A24 | TTLTRG2* | (TTL level bidirectional) |
| Pin A26 | TTLTRG4* | (TTL level bidirectional) |
| Pin A27 | TTLTRG6* | (TTL level bidirectional) |
| Pin C1 | CLK10+ | (ECL level input) |
| Pin C2 | CLK10– | (ECL level input) |
| Pin C23 | TTLTRG1* | (TTL level bidirectional) |
| Pin C24 | TTLTRG3* | (TTL level bidirectional) |
| Pin C26 | TTLTRG5* | (TTL level bidirectional) |
| Pin C27 | TTLTRG7* | (TTL level bidirectional) |

# LED Indicators

| | |
|---|---|
| READY | Unit has passed power-up self-diagnostics.<br>Toggles when unit has an error pending in error queue. |
| VXI | VXI access occurring or VXIbus MODID asserted |
| TRG | Flashes when trigger event occurs |
| BUSY | Unit is busy with one of the following operations:<br>auto-scale, self-calibration, self-test, data capture, download or storage |



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# DC Power

Total Cooling & Power Consumption

| Product Option | Typical Cooling & Power | Maximum Cooling & Power |
|---|---|---|
| **ZT412-20** | 55.4 W | 68.5 W |
| **ZT412-21** | 69.8 W | 82.9 W |
| **ZT412-50** | 57.0 W | 70.1 W |
| **ZT412-51** | 71.4 W | 84.5 W |

Power Supplies

| Product Option | Voltage | Typical Current | Maximum Current |
|---|---|---|---|
| **ZT412-20** | +5V<br>+12V<br>+24V<br>–2V<br>–5.2V<br>–12V<br>–24V | 9.44A<br>0.45A<br>0.0A<br>0.05A<br>0.51A<br>0.0A<br>0.0A | 11.46A<br>0.52A<br>0.0A<br>0.08A<br>0.92A<br>0.0A<br>0.0A |
| **ZT412-21** | +5V<br>+12V<br>+24V<br>–2V<br>–5.2V<br>–12V<br>–24V | 12.32A<br>0.45A<br>0.0A<br>0.05A<br>0.51A<br>0.0A<br>0.0A | 14.34A<br>0.52A<br>0.0A<br>0.08A<br>0.92A<br>0.0A<br>0.0A |
| **ZT412-50** | +5V<br>+12V<br>+24V<br>–2V<br>–5.2V<br>–12V<br>–24V | 9.76A<br>0.45A<br>0.0A<br>0.05A<br>0.51A<br>0.0A<br>0.0A | 11.78A<br>0.52A<br>0.0A<br>0.08A<br>0.92A<br>0.0A<br>0.0A |
| **ZT412-51** | +5V<br>+12V<br>+24V<br>–2V<br>–5.2V<br>–12V<br>–24V | 12.64A<br>0.45A<br>0.0A<br>0.05A<br>0.51A<br>0.0A<br>0.0A | 14.66A<br>0.52A<br>0.0A<br>0.08A<br>0.92A<br>0.0A<br>0.0A |

# Physical

| | |
|---|---|
| Physical size | Single-Wide C-size VXIbus |
| Weight | 3.5 lbs. or 1.59 kg |



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# Temperature Range

| | |
|---|---|
| Operating | 0 °C to +40 °C Ambient |
| Storage | -40 °C to +75 °C |
| Calibration Range | +20 °C to +30 °C Ambient, after a 20 minute warm-up period, to meet all calibration specification accuracies. |

# Relative Humidity

| | |
|---|---|
| Operating or Storage | 10 to 90%, non-condensing, up to +40 °C |

# Altitude

| | |
|---|---|
| Operating | Up to 2,000 m |
| Storage | Up to 15,000 m |



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# Default Reset Conditions




| Parameter | Default |
|---|---|
| Acquisition Mode | Normal |
| Arm Polarity | Positive |
| Arm Source | Immediate |
| Averaging Waveform Count | 8 |
| Averaging Type | Average |
| Calculation Channel Enable | False |
| Calculation Operation | Add Input1 and Input 2 |
| ECL Trigger Outputs | Disabled, Positive Polarity, Trigger Event Source |
| Envelope View | Minimum |
| Equivalent-Time Points | 10 |
| Initiate Continuous | OFF |
| Input Channel Enable | True |
| Input Coupling | DC |
| Input Impedance | 1 MΩ |
| Input Probe Attenuation | 1.0 |
| Input Voltage Offset | 0.0V |
| Input Voltage Range | 10.0Vpp |
| Limit Test Continuous | On |
| Limit Test Lower Limit | 0.0 |
| Limit Test Measurement | AC RMS |



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| Parameter | Default |
|---|---|
| Limit Test Upper Limit | 0.0 |
| Mask Test Lower Source | Reference 1 |
| Mask Test Upper Source | Reference 1 |
| Measurement Edge | 1 |
| Measurement Gate Start Points | 0 |
| Measurement Gate Start Time | 0.0 seconds |
| Measurement Gate Stop Points | 1000 |
| Measurement Gate Stop Time | 10 µs |
| Measurement High Reference Level | 0.9 (90 percent) |
| Measurement Low Reference Level | 0.1 (10 percent) |
| Measurement Method | All |
| Measurement Mid Reference Level | 0.5 (50 percent) |
| Measurement Reference Method | Relative Percentages |
| Pulse Width Trigger High | 2 µs |
| Pulse Width Trigger Low | 1 µs |
| Reference Output | Disabled, Compensation Source (500 Hz) |
| Sample Clock Source | Internal |
| Sample Rate | 100 MHz |
| Sweep Mode (Auto trigger) | Normal |
| Sweep Offset Reference | 0.5 (50 percent) |
| Sweep Offset Time | 0.0 seconds |
| Sweep Points | 1000 |
| Time Base Reference | Internal |
| Transform Frequency Window | Rectangular |
| Transform Time Points | 40 |
| Trigger B Polarity | Positive |



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| Parameter | Default |
|---|---|
| Trigger B Source | Channel 2 |
| Trigger B State | Bypass |
| Trigger Event Count | 1 |
| Trigger Hold Off | 0.0 seconds |
| Trigger Level Channel 1 | 0.0V |
| Trigger Level Channel 2 | 0.0V |
| Trigger Level Channel 3 | 0.0V |
| Trigger Level Channel 4 | 0.0V |
| Trigger Level External | 0.0V |
| Trigger Pattern Mask | 0 |
| Trigger Pattern Truth | 0 |
| Trigger Polarity | Positive |
| Trigger Source | Channel 1 |
| Trigger Type | Edge |
| TTL Trigger Outputs | Disabled, Positive Polarity, Trigger Event Source |
| Video Trigger Field | 1 |
| Video Trigger Line | 1 |
| Video Trigger Standard | NTSC |
| Waveform Byte Order | Normal (MSB First) |



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# Error Codes




The ZT412 maintains an error queue containing codes for faults conditions encountered during unit operation. These codes are listed in the table below along with a brief description of the code meaning. The error log may be read by using the SYSTEM ERROR QUERY.

| Code | Error Summary | Description |
|---|---|---|
| -100 | Command error | A generic syntax error (only used when a more specific error does not apply) |
| -101 | Invalid character | A syntactic element contains a character which is invalid for that type |
| -102 | Syntax error | An unrecognized command or data type was encountered |
| -103 | Invalid separator | The parser was expecting a separator and encountered an illegal character |
| -104 | Data type error | The parser recognized a data element different than the one allowed |
| -105 | Get not allowed | |
| -108 | Parameter not allowed | More parameters were received than expected |
| -109 | Missing parameter | Fewer parameters were received than expected |
| -110 | Command header error | A generic error was detected in the command |
| -111 | Header separator error | A character which was not a legal separator was encountered while parsing the command |
| -112 | Mnemonic too long | The command contains too many characters |
| -113 | Undefined header | The command is correct, but undefined for the specific instrument |
| -114 | Header suffix out-of-range | The suffix number makes the command invalid |
| -118 | Query not allowed | |
| -120 | Numeric data error | A generic numeric syntax error (only used when a more specific error does not apply) |



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| Code | Error Summary | Description |
|---|---|---|
| -121 | Invalid char in number | An invalid character for the data type was encountered |
| -123 | Exponent too large | The magnitude of the exponent was larger than 32000 |
| -124 | Too many digits | The mantissa of a decimal numeric data element contained more than 255 digits excluding zero |
| -128 | Numeric data not allowed | A legal numeric data element was received, but the instrument does not accept one in this position in the command |
| -130 | Suffix error | General command suffix error (only used when a more specific error does not apply) |
| -131 | Invalid suffix | The command suffix is invalid for this instrument |
| -134 | Suffix too long | The command suffix is too long |
| -138 | Suffix not allowed | A suffix was encountered after a numeric element which does not allow suffixes |
| -140 | Character data error | General character data element error (only used when a more specific error does not apply) |
| -141 | Invalid character data | Either a invalid character in the parameter or the character data is not valid for this command |
| -144 | Character data too long | The character parameter contains too many characters |
| -148 | Character data not allowed | The character data is legal but not supported by this instrument |
| -150 | String data error | General data string error (only used when a more specific error does not apply) |
| -151 | Invalid string data | An invalid string command parameter |
| -158 | String data not allowed | A string element was in the wrong place for this instrument command |
| -160 | Block data error | General block data error (only used when a more specific error does not apply) |
| -161 | Invalid block data | An invalid block data element was received for this instrument command |



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| Code | Error Summary | Description |
|---|---|---|
| -168 | Block data not allowed | Block data element not allowed by this instrument command at this parameter |
| -170 | Expression error | General expression error (only used when a more specific error does not apply) |
| -171 | Invalid expression | Invalid expression data element like unmatched parentheses or illegal character |
| -178 | Expression data not allowed | A legal expression was encountered but is not allowed by this instrument in this command |
| -180 | Macro error | General macro error (only used when a more specific error does not apply) |
| -181 | Invalid outside macro | Indicates that a macro parameter placeholder was encountered outside a macro definition |
| -183 | Invalid inside macro | Syntactically invalid message unit sequence |
| -184 | Macro parameter error | The command inside the macro definition had the wrong number or type of parameters |
| -200 | Execution error | General execution error (only used when a more specific error does not apply) |
| -201 | Invalid while in local | Indicates that the command is not executable while the device is in local control |
| -202 | Settings lost due to RTL | The settings were lost when the instrument was returned to local control |
| -203 | Command protected | Indicates that a legal password protected program command or query could not be executed because the command was disabled |
| -210 | Trigger Error | General trigger error |
| -211 | Not ready for trigger | Indicates that a trigger was received by the instrument but was ignored because of timing considerations |
| -212 | Not ready for arm | Indicates that a ARM was received by the instrument but was ignored |
| -213 | Already initiated | Indicates that a measurement request was ignored because another measurement was already in progress |
| -214 | Not ready for trigger | The trigger is deadlocked because a measurement result was requested before the instrument measurement was triggered |



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| Code | Error Summary | Description |
|---|---|---|
| -220 | Parameter error | General program parameter error (only used when a more specific error does not apply) |
| -221 | Settings conflict | Indicates that a legal command was received by the instrument but could not be executed because of the current state of the instrument |
| -222 | Data out of range | Indicates that a valid parameter was received but could not be executed because the parameter is out of range for the instrument |
| -223 | Too much data | The command contained more data than the instrument memory could support |
| -224 | Illegal parameter value | A value outside the list of possible values was received |
| -225 | Out of memory | The instrument contains insufficient memory to perform the requested operation |
| -226 | Lists not the same length | The lists do not have equal lengths |
| -230 | Data corrupt or stale | New reading started but not completed resulting in invalid data |
| -231 | Questionable data | Indicates that there is a problem with the instrument measurement accuracy |
| -232 | Data has invalid format | The command tried to execute using an inappropriate data format or structure |
| -233 | Incompatible version | Indicates that a file version or instrument version is not appropriate for this command |
| -240 | Hardware error | Indicates that a general error occurred because there was a hardware problem in the instrument (only used when a more specific error does not apply) |
| -241 | Hardware missing | Indicates that a command could not be executed because a hardware option is not present |
| -250 | Mass storage error | General mass storage error (only used when a more specific error does not apply) |
| -251 | Missing mass storage | The command could not be executed because an optional mass storage device was not present |
| -252 | Missing media | The command could not be executed because of a missing media (disk) from a storage device |



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| Code | Error Summary | Description |
|---|---|---|
| -253 | Corrupt media | Indicates that the requested media is corrupt (bad or unformatted disk) |
| -254 | Media full | Indicates that the requested media is full |
| -255 | Directory full | Indicates that the requested media directory is full |
| -256 | File name not found | Indicates that the command or query could not be executed because the requested file could not be found |
| -257 | File name error | Indicates that the command or query could not be executed because the requested file was in error |
| -258 | Media protected | Indicates that the requested media is protected |
| -260 | Expression execution failed | General command expression error (only used when a more specific error does not apply) |
| -261 | Math expression execution failed | Indicates that a command tried to perform an illegal math operation |
| -270 | Macro execution error | General macro error (only used when a more specific error does not apply) |
| -271 | Macro syntax error | The command could not be executed because there is an error within the syntax of the macro |
| -272 | Macro execution error | The command could not be executed because there is an error within the macro definition |
| -273 | Illegal macro label | The macro label is not valid for this instrument |
| -274 | Macro parameter error | The macro definition improperly uses a macro parameter placeholder |
| -275 | Macro definition too long | The string or block content of a macro was too long for the instrument |
| -276 | Macro recursion error | The macro program data sequence could not be executed because the instrument found it to be recursive |
| -277 | Macro redefinition not allowed | The command could not be executed because the macro label was already defined |
| -278 | Macro header not found | Could not execute the macro because the macro was not previously defined |



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| Code | Error Summary | Description |
|---|---|---|
| -280 | Program error | General downloaded program error (only used when a more specific error does not apply) |
| -281 | Can not create program | Indicates that the attempt to create a downloaded program was unsuccessful generally due to lack of memory |
| -282 | Illegal program name | The command referenced a nonexistent program or attempted to redefine an existing program |
| -283 | Illegal variable name | An attempt was made to reference a nonexistent program variable |
| -284 | Program currently running | An attempt was made to redefine or delete an existing program while it is running |
| -285 | Program syntax error | Indicates that a syntax error appears in a downloaded program |
| -286 | Program runtime error | A runtime error exists in a downloaded program |
| -290 | Memory usage error | Indicates that the user request has directly or indirectly caused an error related to memory |
| -291 | Out of memory | The instrument memory is full |
| -292 | Reference name does not exist | The reference name does not exist |
| -293 | Reference name already exists | The reference name already exists |
| -294 | Incompatible Type | Indicates that the type or structure of a memory item is inadequate |
| -300 | Device specific error | General instrument error (only used when a more specific error does not apply) |
| -310 | System error | Indicates that an instrument system error has occurred |
| -311 | Memory error | Indicates a physical fault in the instruments memory, such as a parity fault |
| -312 | PUD memory lost | Indicates that the protected user data in the instrument has been lost |
| -313 | Calibration memory corrupted | Indicates that the instruments nonvolatile calibration memory has been lost or corrupted |
| -314 | Configuration memory corrupted | Indicates that the instruments nonvolatile memory that was saved has been lost or corrupted |



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| Code | Error Summary | Description |
|---|---|---|
| -315 | Manufacturing info corrupted | Indicates that the instruments nonvolatile configuration memory has been lost or corrupted |
| -320 | Storage Fault | Indicates that the firmware detected a fault when using data storage. Generally this error does not indicate a hardware error |
| -321 | Out of memory for an internal operation | An internal operation needed more memory than was available |
| -330 | Self test failed | The internal self test failed. This self test is either run on power up or by command |
| -340 | Calibration failed | The instrument internal calibration failed |
| -350 | Queue overflow | This code indicates that there is no room in the queue and an error occurred but was not recorded |
| -360 | Communications error | General instrument communications error (only used when a more specific error does not apply) |
| -361 | Parity error in program message | The serial port parity bit was not correct when data was received |
| -362 | Framing error in program message | A serial port stop bit was not detected when data was received |
| -363 | Input buffer overrun | The input buffer on a serial port overflowed with data caused by improper or nonexistent spacing |
| -400 | Query error | General query error (only used when a more specific error does not apply) |
| -410 | Query interrupt error | Indicates that a command was received before the query was fully executed |
| -420 | Query un-terminated error | An incomplete query command was received |
| -430 | Query deadlock error | The instrument is locked due to a incomplete query command |
| -440 | Query un-terminated after indefinite response | Indicates that a query was received in the same command after a query requesting an indefinite response was executed |
| -500 | Power on | The instrument has detected an off to on transition in its power system |



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| Code | Error Summary | Description |
|---|---|---|
| -600 | User request | The instrument has detected the activation of a user request for local control |
| -700 | Request control | The instrument requested to become the active controller-in-charge |
| -800 | Operation complete | The instrument has completed all selected pending operations |
| -1001 | PLL unlocked | The instrument clock in not locked to the PLL |
| -1002 | Boot Failed | Firmware boot failure detected |
| -1003 | Wave Invalid | Unable to create a desired waveform due to invalid parameter set |



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# Commands Index




The following are alphabetic lists of the commands for the ZT412.

## IEEE-488 Common Commands

| Name | Command Syntax |
|---|---|
| **Calibrate Query** | *CAL? |
| **Clear Status Command** | *CLS |
| **Event Status Enable Command/Query** | *ESE |
| **Event Status Register Query** | *ESR? |
| **Identification Query** | *IDN? |
| **Operation Complete Command/Query** | *OPC |
| **Recall Instrument State Command** | *RCL |
| **Reset Command** | *RST |
| **Save Instrument State Command** | *SAV |
| **Service Request Enable Command/Query** | *SRE |
| **Status Byte Query** | *STB? |
| **Trigger Immediate Command** | *TRG |
| **Test Query** | *TST? |
| **Wait to Continue Command** | *WAI |

## SCPI Instrument Specific Commands

| Name | Command Syntax |
|---|---|
| Abort Command | ABOR |
| Arm Command/Query | ARM[:IMMediate] |
| Arm Polarity Command/Query | ARM:POLarity |
| Arm Source Command/Query | ARM:SOURce |
| Auto Scale Command | [SENSe]:AUToscale |



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| Name | Command Syntax |
|---|---|
| Average Count Command/Query | [SENSe]:AVERage:COUNt |
| Average Envelope View Command/Query | [SENSe]:AVERage:ENVelope:VIEW |
| Average Equivalent Time Points Command/Query | [SENSe]:AVERage:ETIMe:POINts |
| Average State Command/Query | [SENSe]:AVERage[:STATe] |
| Average Type Command/Query | [SENSe]:AVERage:TYPE |
| Calculate Absolute Value Command | CALCulate<n>:AVALue |
| Calculate Add Command | CALCulate<n>:ADD |
| Calculate Copy Command | CALCulate<n>:COPY |
| Calculate Derivative Command | CALCulate<n>:DERivative |
| Calculate Function Query | CALCulate<n>:FUNCtion |
| Calculate Immediate Command | CALCulate<n>:IMMediate |
| Calculate Integral Command | CALCulate<n>:INTegral |
| Calculate Invert Command | CALCulate<n>:INVert |
| Calculate Limit Test Clear Command | CALCulate<n>:LIMit:CLEar |
| Calculate Limit Test Command | CALCulate<n>:LIMit |
| Calculate Limit Test Continuous Command/Query | CALCulate<n>:LIMit:CONTinuous |
| Calculate Limit Test Fail Query | CALCulate<n>:LIMit:FAIL |
| Calculate Limit Test Lower Command/Query | CALCulate<n>:LIMit:LOWer |
| Calculate Limit Test Measurement Command/Query | CALCulate<n>:LIMit:MEASure |
| Calculate Limit Test Report Query | CALCulate<n>:LIMit:REPort |
| Calculate Limit Test Upper Command/Query | CALCulate<n>:LIMit:UPPer |
| Calculate Mask Test Lower Command/Query | CALCulate<n>:LIMit:MASK:LOWer |
| Calculate Mask Test Upper Command/Query | CALCulate<n>:LIMit:MASK:UPPer |
| Calculate Multiply Command | CALCulate<n>:MULTiply |
| Calculate State Command/Query | CALCulate<n>[:STATe] |
| Calculate Subtract Command | CALCulate<n>:SUBTract |
| Calculate Transform Frequency Command | CALCulate<n>:TRANsform:FREQuency |
| Calculate Transform Frequency Window Command/Query | CALCulate<n>:TRANsform:FREQuency:WINDow |
| Calculate Transform Time Command | CALCulate<n>:TRANsform:TIME |



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| Name | Command Syntax |
|---|---|
| Calculate Transform Time Points Command/Query | CALCulate<n>:TRANsform:TIME:POINts |
| Calculate Voltage Offset Command/Query | CALCulate<n>:OFFSet |
| Calculate Voltage Range Command/Query | CALCulate<n>:RANGe |
| Calibration Restore Command | CALibration:RESTore |
| Calibration Skew Command/Query | CALibration:SKEW |
| Clock Frequency Command/Query | [SENSe]:SWEep:CLOCk:FREQuency |
| Clock Source Command/Query | [SENSe]:SWEep:CLOCk:SOURce |
| Format Byte Command/Query | FORMat:BORDer |
| Initiate Command/Query | INITiate[:IMMediate] |
| Initiate Continuous Command/Query | INITiate:CONTinuous |
| Input Attenuation Command/Query | [SENSe]:INPut<n>:ATTenuation |
| Input Coupling Command/Query | [SENSe]:INPut<n>:COUPling |
| Input Filter State Command/Query | [SENSe]:INPut<n>:FILTer[:LPASs][:STATe] |
| Input Impedance Command/Query | SENSe]:INPut<n>:IMPedance |
| Input State Command/Query | [SENSe]:INPut<n>[:STATe] |
| Input Voltage Offset Command/Query | [SENSe]:VOLTage<n>:RANGe:OFFSet |
| Input Voltage Protection State Command/Query | [SENSe]:VOLTage<n>:PROTection[:STATe] |
| Input Voltage Range Command/Query | [SENSe]:VOLTage<n>:RANGe:PTPeak |
| Measure AC RMS Query | MEASure:VOLTage:AC |
| Measure Amplitude Query | MEASure:VOLTage:AMPLitude |
| Measure Average Voltage Query | MEASure:VOLTage:AVERage |
| Measure Cycle Average Query | MEASure:VOLTage:CAVerage |
| Measure Cycle Frequency Query | MEASure:VOLTage:CFRequency |
| Measure Cycle Period Query | MEASure:VOLTage:CPERiod |
| Measure Cycle RMS Query | MEASure:VOLTage:CRMS |
| Measure DC RMS Query | MEASure:VOLTage:DC |
| Measure Edge Command/Query | MEASure:EDGE |
| Measure Effective Number of Bits Query | MEASure:VOLTage:ENOB |
| Measure Fall Crossing Time Query | MEASure:VOLTage:FTCRoss |
| Measure Fall Overshoot Time Query | MEASure:VOLTage:FOVershoot |
| Measure Fall Preshoot Time Query | MEASure:VOLTage:FPReshoot |
| Measure Fall Time Query | MEASure:VOLTage:FTIMe |



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| Name | Command Syntax |
|---|---|
| Measure Frequency Query | MEASure:VOLTage:FREQuency |
| Measure Gate Points Command/Query | MEASure:GATE:POINts |
| Measure Gate Time Command/Query | MEASure:GATE[:TIME] |
| Measure High Voltage Query | MEASure:VOLTage:HIGH |
| Measure Low Voltage Query | MEASure:VOLTage:LOW |
| Measure Maximum Voltage Query | MEASure:VOLTage:MAXimum |
| Measure Method Command/Query | MEASure:METHod |
| Measure Mid Voltage Query | MEASure:VOLTage:MID |
| Measure Minimum Voltage Query | MEASure:VOLTage:MINimum |
| Measure Negative Duty Cycle Query | MEASure:VOLTage:NDUTycycle |
| Measure Negative Width Query | MEASure:VOLTage:NWIDth |
| Measure Peak-To-Peak Voltage Query | MEASure:VOLTage:PTPeak |
| Measure Period Query | MEASure:VOLTage:PERiod |
| Measure Phase Query | MEASure:VOLTage:PHASe |
| Measure Positive Duty Cycle Query | MEASure:VOLTage:PDUTycycle |
| Measure Positive Width Query | MEASure:VOLTage:PWIDth |
| Measure Precision AC Query | MEASure:VOLTage:PAC |
| Measure Precision DC Query | MEASure:VOLTage:PDC |
| Measure Reference Command/Query | MEASure:REFerence |
| Measure Reference Method Command/Query | MEASure:REFerence:METHod |
| Measure Rise Crossing Time Query | MEASure:VOLTage:RTCRoss |
| Measure Rise Overshoot Query | MEASure:VOLTage:ROVershoot |
| Measure Rise Preshoot Query | MEASure:VOLTage:RPReshoot |
| Measure Rise Time Query | MEASure:VOLTage:RTIMe |
| Measure Signal-to-Noise Ratio Query | MEASure:VOLTage:SNR |
| Measure Signal-to-Noise & Distortion Ratio Query | MEASure:VOLTage:SNDR |
| Measure Spurious-Free Dynamic Range Query | MEASure:VOLTage:SFDR |
| Measure Time of Maximum Voltage Query | MEASure:VOLTage:TMAXimum |
| Measure Time of Minimum Voltage Query | MEASure:VOLTage:TMINimum |
| Measure Total Harmonic Distortion Query | MEASure:VOLTage:THD |
| Output ECL Trigger Polarity Command/Query | OUTPut:ECLTrg<n>:POLarity |



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| Name | Command Syntax |
|---|---|
| Output ECL Trigger Source Command/Query | OUTPut:ECLTrg<n>:SOURce |
| Output ECL Trigger State Command/Query | OUTPut:ECLTrg<n>[:STATe] |
| Output TTL Trigger Polarity Command/Query | OUTPut:TTLTrg<n>:POLarity |
| Output TTL Trigger Source Command/Query | OUTPut:TTLTrg<n>:SOURce |
| Output TTL Trigger State Command/Query | OUTPut:TTLTrg<n>[:STATe] |
| Output Reference Source Command/Query | OUTPut:REFerence:SOURce |
| Output Reference State Command/Query | OUTPut:REFerence[:STATe] |
| Reference Oscillator Source Command/Query | [SENSe]:ROSCillator:SOURce |
| Status Calibration Condition Query | STATus:QUEStionable:CALibration:CONDition |
| Status Calibration Enable Command/Query | STATus:QUEStionable:CALibration:ENABle |
| Status Calibration Event Query | STATus:QUEStionable:CALibration [:EVENt] |
| Status Frequency Condition Query | STATus:QUEStionable:FREQuency:CONDition |
| Status Frequency Enable Command/Query | STATus:QUEStionable:FREQuency:ENABle |
| Status Frequency Event Query | STATus:QUEStionable:FREQuency[:EVENt] |
| Status Operation Condition Query | STATus:OPERation:CONDition |
| Status Operation Enable Command/Query | STATus:OPERation:ENABle |
| Status Operation Event Query | STATus:OPERation[:EVENt] |
| Status Preset Command | STATus:PRESet |
| Status Questionable Condition Query | STATus:QUEStionable:CONDition |
| Status Questionable Enable Command/Query | STATus:QUEStionable:ENABle |
| Status Questionable Event Query | STATus:QUEStionable[:EVENt] |
| Status Test Condition Query | STATus:QUEStionable:TEST:CONDition |
| Status Test Enable Command/Query | STATus:QUEStionable:TEST:ENABle |
| Status Test Event Query | STATus:QUEStionable:TEST[:EVENt] |
| Status Voltage Condition Query | STATus:QUEStionable:VOLTage:CONDition |
| Status Voltage Enable Command/Query | STATus:QUEStionable:VOLTage:ENABle |
| Status Voltage Event Query | STATus:QUEStionable:VOLTage[:EVENt] |
| Sweep Mode Command/Query | [SENSe]:SWEep:MODE |



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| Name | Command Syntax |
|---|---|
| Sweep Offset Reference Command/Query | [SENSe]:SWEep:OREFerence:LOCation |
| Sweep Offset Time Command/Query | [SENSe]:SWEep:OFFSet:TIME |
| Sweep Points Command/Query | [SENSe]:SWEep:POINts |
| Sweep Time Query | [SENSe]:SWEep:TIME |
| System Error All Query | SYSTem:ERRor:ALL |
| System Error Count Query | SYSTem:ERRor:COUNt |
| System Error Query | SYSTem:ERRor[:NEXT] |
| System Memory Query | SYSTem:MEMory |
| System Version Query | SYSTem:VERSion |
| Trace Copy Reference Command | TRACe:COPY:REFerence<n> |
| Trace Data Command/Query | TRACe[:DATA] |
| Trace Load Calculate Query | TRACe:LOAD:CALCulate<n> |
| Trace Load Input Query | TRACe:LOAD:INPut<n> |
| Trace Load Reference Command/Query | TRACe:LOAD:REFerence<n> |
| Trace Preamble Command/Query | TRACe:PREamble |
| Trigger A Event Count Command/Query | TRIGger[:A]:ECOunt |
| Trigger A Pulse High Limit Command/Query | TRIGger[:A]:PULSe:HLIMit |
| Trigger A Pulse Low Limit Command/Query | TRIGger[:A]:PULSe:LLIMit |
| Trigger A Slope Command/Query | TRIGger[:A]:SLOPe |
| Trigger A Source Command/Query | TRIGger[:A]:SOURce |
| Trigger A Type Command/Query | TRIGger[:A]:TYPE |
| Trigger A Video Field Command/Query | TRIGger[:A]:VIDeo:FIELd |
| Trigger A Video Line Command/Query | TRIGger[:A]:VIDeo:LINE |
| Trigger A Video Standard Command/Query | TRIGger[:A]:VIDeo:STANdard |
| Trigger B Slope Command/Query | TRIGger:B:SLOPe |
| Trigger B Source Command/Query | TRIGger:B:SOURce |
| Trigger B State Command/Query | TRIGger:B[:STATe] |
| Trigger External Level Command/Query | TRIGger:EXTernal:LEVel |
| Trigger Hold Off Command/Query | TRIGger:HOLDoff |
| Trigger Input Level Command/Query | TRIGger:INPut<n>:LEVel |
| Trigger Pattern Mask Command/Query | TRIGger:PATTern:MASK |
| Trigger Pattern Truth Command/Query | TRIGger:PATTern:TRUTh |



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| Name | Command Syntax |
| --- | --- |
| Trigger Timestamp Query | TRIGger:TIMestamp |



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